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OF  
The Entomological Society of America

VOLUME XLII, 1949

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# ANNALS

OF

## The Entomological Society of America

Volume XLII

MARCH, 1949

No. 1

### THE CLASSIFICATION OF INSECTS<sup>1</sup>

CLARENCE E. MICKEL

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The living organisms that inhabit the earth in colossal numbers are incomprehensible to us either as a whole or in part unless they are arranged or classified in some sort of systematic way. It is not surprising then to find that attempts to classify the living world extend far back into the distant past and that our present classifications are the result of a long period of growth and development. The earliest ideas regarding classification of which we have any record are those of Aristotle (384-322 B. C.). He did not concern himself with formulating any definite outline of classification, but as one reads his written works it is evident that he had definite ideas regarding the systematic arrangement of the living things known to him. With reference to the insects he recognized and differentiated between the wingless ones and those with wings. He undoubtedly included many animals among the wingless insects that we do not consider as insects today. Among the winged insects he recognized distinct groups, some of them comparable to our orders of insects, on the basis of the number of wings, texture of wings and vestiture of wings.

Aristotle's written works were regarded as an infallible source of knowledge of natural history for centuries. It was not until after the invention of printing and the revival of learning in the middle ages that any new contribution was made. One of the first attempts to give a complete account of the insects was a book by an Italian Professor, Ulysses Aldrovandus (1522-1607). His book on the insects, "*De animalibus insectis libri septem*," was published in 1602. At the beginning of this book there is an outline which sets forth Aldrovandi's proposals regarding classification of the insects. He did not use the presence or absence of wings, nor the characteristics of the wings as the primary basis for arrangement and definition of groups. His first division separated insects into two ecological groups, those terrestrial

<sup>1</sup>Paper No. 2415, Scientific Journal Series, Minnesota Agricultural Experiment Station, St. Paul 1, Minnesota.

and those aquatic. Each of these was further subdivided on the basis of legs present or absent, and if present, the actual number of legs. Finally the number and nature of the wings were taken into account. Undoubtedly the lack of emphasis on wings and their nature as insect characteristics was due to the fact that the term "insects" was an exceedingly broad one and included many animals not considered by us as insects. Crustaceans, molluscs, worms, starfish and even the sea horse (a fish) were all included in this book on insects and were so defined by him.

Aldrovandi's book was the standard reference work for one hundred years or more and during this period Swammerdam (1637-1680) made his famous studies on metamorphosis. Swammerdam, in a book entitled "*Historia insectorum generalis*" published in 1669, suggested that metamorphosis might serve as a primary basis for the classification of insects and that four groups of insects could thus be recognized. He did not, however, propose any formal classification.

John Ray (1628-1705) and Francis Willoughby (1635-1672) working in England attempted to apply Swammerdam's ideas to insect classification, although Willoughby died many years before the results of their work were published. Ray's classification was published in "*Methodus insectorum, etc.*" in 1705. The four kinds of metamorphosis suggested by Swammerdam were used as the primary divisions and Aldrovandi's classification was added to this almost unchanged. The term "insects" was still used in the same broad sense as it had been used by Aldrovandi, and included many invertebrate animals that are today arranged in other classes and phyla.

Two years after Ray's death Linnaeus (1707-1778) was born in Sweden. He was destined to influence and change the whole course of natural history to a greater extent than anyone since the time of Aristotle. He introduced and established the system of binary nomenclature, reducing the long Latin phrases which had previously been used for names of animals and plants to two Latin words, a generic name and a specific name. He introduced definite categories or ranks into the classification of organisms. Thus, genera were composed of species, orders were made up of genera, a class included one or more orders, and a kingdom was subdivided into classes. The insects were given the rank of a class.

Linnaeus made two distinct advances in the classification of the insects which laid a foundation for further advancement and improvement. First, the definition of the class Insecta was limited so that many of the invertebrate animals formerly regarded as insects, such as molluscs, worms, etc., were removed to other classes; second, the elimination of many of these non-insect animals left Linnaeus free to formulate a classification of the insects on the basis of their unique and most characteristic structures, the wings. The idea was not new, it had already been suggested by Aristotle two thousand years before, but Linnaeus sensed its fundamental nature, resurrected it and applied it anew. His class Insecta was made up of seven orders: the Aptera, without wings; the Diptera, with two wings; two orders with four

membranous wings, the Hymenoptera with a sting (ovipositor), and the Neuroptera without a sting; the Lepidoptera, with four wings imbricated with scales; the Hemiptera, with four wings, the front pair semicrustaceous; and the Coleoptera, with four wings, the front pair crustaceous.

The innovations of nomenclature, systematic ranking and classification introduced by Linnaeus were a tremendous stimulus to the study of natural history because they facilitated thinking, talking and writing about the objects of natural science. The tempo of investigation and discovery was greatly increased and the number of known species of animals and plants multiplied by leaps and bounds.

Linnaeus was a great teacher as well as a great naturalist. Students traveled to Upsala, Sweden from all parts of Europe to study with him. Among these students was one, John Christian Fabricius (1742-1808), who was primarily concerned with entomology. He spent two years with Linnaeus and then returned to Denmark where he published a long series of taxonomic works on the various orders of insects. Fabricius was greatly impressed with the structure of the mouth parts of insects and proposed a system of classification based entirely on the maxillae. His class Insecta was made up of thirteen orders, four of which included Crustacea, Myriapoda and Arachnida. The nine others included insects, in the strict sense, and were the same as the Linnaean orders, except that two additional ones were included, the Orthoptera and Odonata.

Linnaeus had based his system of classification of the insects on wings and indicated the fact by using ordinal names expressing the wing characters, thus: *lepid*=a scale, *pteron*=wing; Lepidoptera=scaly winged insects. Fabricius followed the same custom and gave all his orders new names which expressed the maxillary characters used. He selected the Greek word *gnatha*=lower jaw, to refer to the maxillae and combined it in modified form with various prefixes to form ordinal names, thus: *kleistos*=closed, *gnatha*=jaw: Kleistognatha, for certain Crustacea; *odous*=tooth, and *gnatha*: Odonata for the dragonflies; and *piezo*=to press, and *gnatha*: Piezata for the Hymenoptera. The mouth parts are undoubtedly one of the important sets of structures upon which insect classification is based, but they are only one of many characters which must be considered. It is not strange, therefore, that Fabricius' classification did not survive for it had a still narrower basis, the maxillae. Since the classification did not survive, neither did the names and all have fallen into the discard, except Odonata for the dragonflies.

The deficiencies of both the Linnaean alary system and the Fabrician maxillary system served to emphasize the point that a natural classification cannot be based on a single morphological structure, but at the same time each of them focused attention on a single set of structures which were of fundamental importance and neither of which could ever be ignored in the future in insect classification. Both Linnaeus and Fabricius were popular among the scientists and naturalists of their day, Linnaeus particularly popular with the botanists and



Fabricius with all those interested in entomology. The work of both was a great stimulus to the study of natural history and gave tremendous impetus to the study of insects.

The restriction of the class *Insecta* to animals with three distinct body regions, three pairs of legs, and usually two pairs of wings was brought about by Latreille (1762-1833) at the suggestion of Cuvier (1769-1832). The *Crustacea* were proposed as a class by Latreille in 1806-07 in "*Genera Crustaceorum et Insectorum, etc.*," the *Arachnida* in 1810 in "*Considerations generales—les classes des Crustacés, des Arachnides et des Insectes, etc.*," and the *Myriapoda* in 1825 in "*Familles naturelles du regne animal.*" Latreille gradually modified the Linnaean and Fabrician systems of classification so that by 1831 he recognized four classes, *Crustacea*, *Arachnida*, *Myriapoda* and *Insecta*, with the latter arranged in twelve orders. His classification was based on wings, mouth parts and metamorphosis, a combination of the ideas of Swammerdam, Linnaeus and Fabricius.

Cuvier also suggested a new category to be placed between the order and the genus, and termed it the family. Latreille accepted and applied this suggestion to the insects, the category family being used in all his published works beginning with that in 1806-07 cited above.

Charles Darwin's "*Origin of species*" appeared in the year 1859. The implications of the theories of evolution and natural selection began from that time to penetrate all fields of biological thought. This was especially true of classification or taxonomy because Darwin's book dealt directly with the primary problem of the taxonomist—How do species come about in nature? One of the earliest manifestations of the influence of Darwin's theories on classification was the invention of family tree diagrams by Haeckel in 1866 to illustrate phylogenetic lines of descent, and his introduction of a new category, the phylum, intermediate between kingdom and class. The impact of Darwinian thought on insect classification was undoubtedly more or less immediate, but the first results were not evident until 1885.

Twenty-six years after the publication of the "*Origin of Species*" Friedrich Moritz Brauer (1832-1904) published an essay in 1885 "*Systematische-Zoologische Studien*" in which he proposed a new classification of insects. This work is a milestone in the history of insect classification. It separates sharply two entirely different modes of thought and approach to the problems of insect classification. The predominating thought underlying all attempts to formulate a classification of insects had been that some single morphological structure could be found that would reveal a natural system (the idea of the Creator) of classification. With Swammerdam, it was metamorphosis, with Linnaeus it was undoubtedly the wings of insects, and the mouth parts, or strictly speaking, the maxillae, were the revealing character to Fabricius. Latreille used a combination of all three. Beginning with Brauer the objective has been to formulate a classification of insects in accord with phylogenetic principles, one which would take into account all the morphological structures of the insect and their modifications, and interpret them in the light of evolutionary theory.

Brauer based his classification on a number of characters: (a) presence or absence of wings; (b) number of Malpighian tubules; (c) metamorphosis; (d) mouth parts and their changes during ontogeny; (e) nature of the wings; (f) relative development of the thoracic segments. He arranged the insects in two subclasses. The Apterogogenea included those insects which are wingless and which have probably descended from ancestors that never had wings. This class had only the one order, Synaptera, the most primitive and presumably oldest insects. It included both Thysanura and Collembola. All other insects were placed in the subclass Pterogogenea, the winged insects, or if wingless at the present time, they have descended from ancestors that once had wings. This subclass was made up of sixteen additional orders of insects. Using the morphological criteria he had set up for a guide, he arranged these sixteen orders in a series beginning with the most primitive, the most generalized and the oldest geologically, and terminating with the most specialized and recent.

Brauer's system forms the basis for all modern classifications of insects. His system has been modified by various authors in different ways. The number of orders recognized in each subclass has been increased. The greatest changes have been made in the Pterogogenea as the result of attempts to express the phylogenetic relationships of the various orders more satisfactorily. Two fields of research have contributed greatly to modern views regarding the phylogeny of insects, the tremendous advances in our knowledge of fossil insects made by Scudder, Handlirsch, Tillyard and Carpenter, and studies in comparative morphology by Comstock, Crampton and many others. Probably no period in the world's history has seen as many new facts added to our knowledge of insects as that from Brauer's time until the present, yet the fundamental features of his insect classification are still considered valid. The modifications which have been made only add to its value and increase the scope of its usefulness, but have not introduced any new fundamental conceptions on which some entirely different type of classification could be based. The principal modifications have been proposed by Comstock (1895, 1910, 1924), Sharp (1898), Handlirsch (1906, 1925), Brues and Melander (1915, 1932), Crampton (1922, 1928, 1938), Martynov (1923, 1925), Imms (1925) and Tillyard (1926).

The system of classification adopted here is modified from the proposals of Martynov and Crampton. It has been chosen because it appears to reflect the phylogenetic development and relationships of the winged insects as accurately as our entomological knowledge permits. The principal differences from that of Brauer's system are: 1. The recognition of the Paleopterygotan insects which cannot fold their wings over the abdomen in repose as more primitive and older than the Neopterygota which fold their wings over the abdomen in repose, first proposed by Martynov and Crampton independently; 2. The grouping of certain orders in superordinal complexes to indicate close phylogenetic affinities, as proposed by Crampton; 3. The recogni-

tion of many more orders; and 4. A different linear arrangement of orders to express better phylogenetic relationships.

## SYNOPSIS

## Phylum ARTHROPODA

## Class INSECTA

## Subclass APTERYGOTA

- Order 1. PROTURA
- " 2. THYSANURA
- " 3. COLLEMBOLA

## Subclass PTERYGOTA

## PALEOPTERYGOTA

- Order 4. EPHEMEROPTERA
- " 5. ODONATA

## NEOPTERYGOTA

## Heterometabola

## Isopteroid Insects

- Order 6. BLATTARIAE
- " 7. MANTODEA
- " 8. ISOPTERA

## Plecopteroid Insects

- Order 9. PLECOPTERA
- " 10. EMBIIDINA

## Orthopteroid Insects

- Order 11. ORTHOPTERA
- " 12. PHASMIDA
- " 13. DERMAPTERA

## Psocopteroid Insects

- Order 14. CORRODENTIA
- " 15. MALLOPHAGA
- " 16. ANOPLURA

## Hemipteroid Insects

- Order 17. THYSANOPTERA
- " 18. HEMIPTERA
- " 19. HOMOPTERA

## Holometabola

## Coleopteroid Insects

- Order 20. COLEOPTERA
- " 21. STREPSIPTERA

## Neuropteroid Insects

- Order 22. NEUROPTERA
- " 23. MECOPTERA
- " 24. HYMENOPTERA
- " 25. DIPTERA
- " 26. SIPHONAPTERA
- " 27. TRICHOPTERA
- " 28. LEPIDOPTERA

# A NOTABLE AGGREGATION OF COLLEMBOLA<sup>1</sup>

ORLANDO PARK  
Northwestern University

In general, podurid and entomobryid springtails and oribatid mites are the most abundant arthropods in the litter of the forest floor and are important in the overall formation of organic soil (Allee, Emerson, Park, Park and Schmidt, 1949). On occasion, certain species of springtails have been reported as forming aggregations of almost incredible numbers of individuals. Elton (1927, p. 109), for example, states that swarms of collembolans are said to have held up a Swiss train, the minute insects covering the rails so heavily that the driving-wheels of the locomotive revolved ineffectually.

The most circumstantial accounts of such aggregations known to the author are those described by Macnamara (1919) in Ontario, and one of these, in particular, will be referred to presently.

The purpose of the present paper is to describe quantitatively an aggregation of *Achorutes*. At 10:30 a. m., December 7, 1946, a workman, Adam Rokocinski, noticed a "lot of pinkish bugs" pouring from a small hole in the sod of Dyche field on the University campus. There were three such holes in an area of six square feet, from all of which the insects were emerging. A small pile of soil at the lip of one hole and about one-third of the clustered "bugs" at this orifice were put in a can and brought to the author. The insects were stated to have gone down the holes "like ants" about 3:00 p. m. of the same day.

Examination of the container demonstrated very large numbers of Collembola (Fig. 1). The soil fraction weighed dry was 59.006 grams. The springtails were measured volumetrically in alcohol, in a graduated cylinder of 5 c.c., calibrated to tenths c.c. A sample of 25,000 was counted, and measured 1.92 c.c. in the cylinder. The whole collembolan fraction measured 35.44 c.c. This whole fraction was obtained by measuring thirteen additional samples in the small cylinder, and adding the samples to avoid undue packing of the insects in the cylinder, which might introduce too great an error.

The following populations were estimated on the basis of the counted sample of 25,000, and then checked against a second counted sample of 8,000. It was estimated that the 59.006 grams of dry soil held a minimal population of 450,000 springtails. This is a conservative figure, since it does not take into account great numbers of individuals that were lost in picking up the initial sample, and which might bring the total to 600,000 or more as noted in an advance abstract (Park, 1947).

<sup>1</sup>I thank Dr. Harlow B. Mills, Illinois Natural History Survey, for the identification of the material; Dr. Eliot C. Williams, Jr., Wabash College, for the photograph; Miss Marie Wilson, Northwestern University, for the drawing; and Mr. Lawrence Jones, Northwestern University, for assistance in counting samples of the population.

On the basis of the estimate of 450,000 collembolans in the sample, this would give a conservative population of 1,350,000 per exit hole, and for the three holes in an area of six square feet, the minimal population would be 4,050,000. At the time the sample was collected the author was away, and the opportunity was lost to study this large aggregation in the field.

No collembolans were found on the following day, or for several days afterwards. They appeared to have vanished and the search was stopped. The three exit holes appeared to belong to abandoned burrows of the local ground squirrel, *Citellus tridecemlineatus*. An



FIG. 1. Photograph of the sample. Jar at left holds the soil fraction of about 59 grams, dry weight. Jar at right holds about 450,000 collembolans.

explanation of the aggregation is that the nest materials and food scraps of the rodents formed an excellent source of nourishment for the initial springtail immigrants. In time, this decomposing herbaceous mold would be eaten by the rapidly increasing population, and the insects would emigrate from the burrows.

This general explanation was offered by Macnamara for eruptions of *Achorutes socialis* and its congeners (l.c., p. 269) with the exception that the springtails were said to have continued to spread from the overcrowded habitat niche until it was wholly abandoned. In the present instance the insects were stated by the workman to have returned to the burrows in the afternoon. This is possible, but the author feels that the latter observation may have been misinterpreted; that, instead,

the collembolans continued to mill about the holes and to move away. If so, the population density must have been much larger than estimated, possibly on the order of 9,000,000 per square meter in the immediate vicinity of the exit holes.

These collembolans were identified tentatively as *Achorutes bengtssoni* Agren (Fig. 2). As noted by Dr. Mills, this is a European species seen only once previously by him from North America. In Europe this species is found in the north and under Alpine conditions farther south. Many springtails have a holarctic distribution and this record of *bengtssoni* in northern Illinois appears to exemplify this principle.

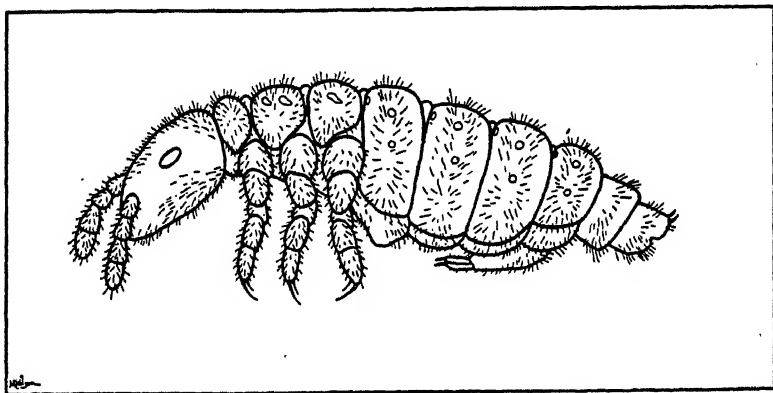


FIG. 2. Left lateral aspect of *Achorutes bengtssoni* Agren.

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PRESERVATION OF GRAINS IN STORAGE, by STEPHEN S. EASTER (Editor).  
FAO Agric. Studies No. 2, iv+174 pages, 4 charts, 2 figs. 1948. Price, \$1.50.

This volume consists of a series of seventeen papers presented at a meeting of the Food and Agriculture Organization of the United Nations in London, England, during August, 1947. Four of these deal specifically with insect pests of stored grains, another considers the need for research on stored grain insect problems, and several others deal partly with the entomological phase of the subject. The volume treats the problem of stored grain pests from an international standpoint; consequently, the entomological aspects of international commerce involving grains is considered.—M. T. J.

## SOME NEW AND POORLY KNOWN THEREVIDAE (DIPTERA) FROM COLORADO

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This paper is presented in order to describe a new species of *Psilocephala* and to clarify the status of the species of the *pygmaea* group of *Thereva*.

### *Psilocephala montiradicis* n. sp.

*Male*.—Head black. Frons except lower angles shining; a subshining area clothed with short stiff yellow pile immediately below each eye; head otherwise whitish pollinose with silky white hairs. Bristles of occiput mostly yellow; some black setulae on occiput above. Eyes broadly contiguous. Ratio of antennal segments 11: 4: 15; flagellum gradually tapering to its style; scape with bristles and bristle-like hairs, most of which are black; pedicel and basal third of flagellum except on its outer face with black bristle-like hairs. Proboscis black with whitish pollen and silky whitish hairs.

Thorax black; mesonotum brownish pollinose, the pollen more whitish on notopleura and above wing bases; a pair of whitish vittae extending from neck to base of scutellum; scutellum whitish pollinose laterally and apically, brownish at base, subshining at extreme apex; pleura whitish pollinose. Pile mostly silvery whitish; that of mesonotum sparse, with sometimes a few blackish hairs; bristles black.

Coxae black, whitish pollinose; trochanters and femora black, their extreme apices reddish yellow, their pile yellowish, appressed, but some, especially ventrally, silky, whitish, erect; tibiae reddish yellow, approximately the apical third of front pair and extreme apices of middle and hind pair blackish, bristles and most hairs black; front tarsus blackish; middle and hind tarsi brownish, their basitarsi and sometimes second segments reddish yellow; tarsal hairs black. Wings whitish, subhyaline, stigma and veins brown, veins yellowish toward base; vein  $R_4$  moderately sinuous; cell  $M_2$  closed and petiolate. Halteres blackish, stems yellowish-brown.

Abdomen black; pregenital segments wholly densely whitish pollinose and with silky whitish hairs; ninth tergum blackish, lightly whitish pollinose; ninth sternum subshining, mostly blackish, broadly divided to base ventrally, each part with two apical lobes which become reddish yellow, the upper bearing a tuft of long straight yellowish hairs; genitalia otherwise reddish yellow; forceps (fig. 1) somewhat boot-like, with apex acute; pile of genitalia mostly yellow to whitish, two to four yellow to black bristles on each side at lower corners of ninth sternum.

Length, 7–9 mm.

*Female*.—Frontal callus shining black, not quite reaching ocellar triangle, the upper part of frons transversely wrinkled; face, a triangle at each lower corner of front, and occiput whitish pollinose; ocellar triangle, vertex, and front above callus subshining, becoming whitish pollinose laterally; two to five black setae in a row on front on each side above callus; stiff hairs of subshining spot below cheek black. Vertex, front at antennal bases, and head width in ratio of 11:26:50. Thoracic pile shorter than in male and with more short black pile dorsally. Tibiae usually more broadly black apically than in male, sometimes entirely black. Wing veins broadly margined with brownish; costal and marginal cells mostly brown. Abdomen shining, becoming subshining laterally and ventrally and whitish pollinose ventrally at base; blackish, apex of second tergum yellowish; with scattered appressed yellowish hairs and with short erect black hairs from second sternum and third tergum on. Length, 7–9 mm.

*Holotype*, male.—Fort Collins, Colorado, May 2, 1940 (M. T. James); Colorado A.&M. College Collection. *Allotype*, female.—Fort Collins, Colorado, May 23, 1941 (James). *Paratypes*.—Fort Collins,

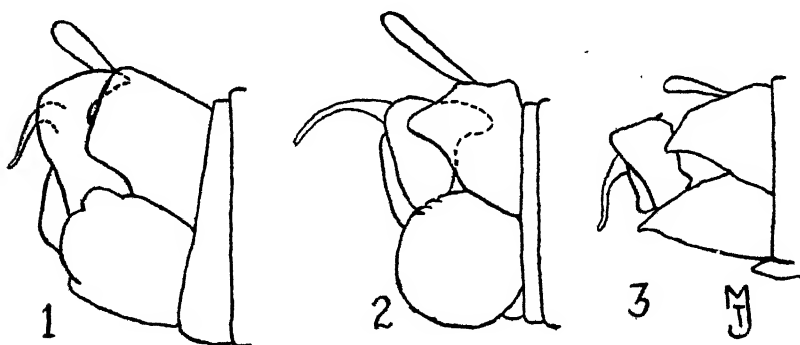


FIG. 1. Male genitalia, in outline, lateral view, of *Psilocephala montiradicis*.

FIG. 2. Same of *Thereva xanthobasis*.

FIG. 3. Same of *Thereva pygmaea*.

Colorado, June 15, 1937 (M. T. & H. B. James), June 2, 1939, May 2, 1940, May 23, 1941, and June 3, 1941 (all M. T. James), 5 males, 5 females.

Some variations appears in specimens of the type series. Freshly emerged individuals have a greater amount of soft pale pile. One male paratype has the front tibiae wholly black and the pile on the subshining spot below the eyes blackish.

In Cole's keys the female traces to *P. costalis* except that the bases of all tibiae may be reddish; the male traces to *argentifrons* but the frons is largely shining, at least the middle and hind tibiae are largely reddish yellow, and the genitalia are largely reddish, shorter and more compact, and structurally quite different.



*Thereva xanthobasis* n. sp.

*Male*.—Head black, wholly whitish pollinose, pollen sparse on front so that this area, except laterally, appears subshining. Pile of vertical triangle, frons, and upper part of facial orbits black, that of frons almost as long as antennal scape and pedicel combined; pile of above areas mostly stiff and more or less bristle-like, that of face becoming whitish and more silky; that of cheeks, proboscis, and occiput whitish and silky; occipital bristles short, mostly pale, a few black ones above. Antennal ratio 12: 3: 6; scape and pedicel with black hairs and bristles, the former sometimes with a few pale ones below at base; flagellum pear-shaped, a few black setulae near its base.

Thorax black, wholly whitish pilose and almost entirely whitish pollinose; two rather poorly defined dorsal vittae of denser, somewhat more yellowish pollen; usual bristles black. Legs mostly black; middle and hind tibiae except apices, fore tibia on basal third to half, and middle and hind basitarsi except apices yellowish; coxae whitish pollinose, femora less densely so; pile of coxae and femora whitish and silky as on thorax, that of tibiae and tarsi short, black. Halteres reddish brown, knobs somewhat darker. Wings hyaline; veins yellowish on basal half, becoming darker apically; vein  $R_4$  moderately sinuate; cell  $M_3$  closed in margin or short petiolate.

Abdomen black; pregenital segments wholly silvery pollinose and whitish pilose; genitalia short, robust; ninth tergum except apex, ninth sternum, and upper outer part of outer forceps blackish, thinly whitish pollinose; pile and bristles of genitalia whitish. Ninth sternum divided into two almost semiglobular lobes; ninth tergum becoming thin and yellowish on upper apical margin, its apex prolonged into a digitate process; outer forceps boot-like in outline.

Length, 6–6.5 mm.

*Holotype*, male.—Fort Collins, Colorado, October 8, 1931; Colorado A. & M. College Collection. *Paratypes*.—Fort Collins, Colorado, September 26 and August 10, 1931, 2 males.

This is a *Psilocephala*-like species, of the *Thereva pygmaea* group. In Cole's key it runs to *melanoneura*, from which it may be distinguished by the characters given in my key and by the quite different structure of the male genitalia (fig. 2).

*Thereva pygmaea* Cole

*Thereva pygmaea* Cole, 1923, Proc. U. S. Nat. Mus., 62: 89–91.

Cole does not describe the genitalia of this species and his illustration does not show the structure in sufficient detail. Moreover, the true nature of the thoracic pollen is not indicated. The following notes, which should facilitate identification and indicate more exactly the range of variation, were based on a series which I at first thought to be a new species. I am indebted to Mr. Curtis W. Sabrosky, Division of Insect Identification, Bureau of Entomology and Plant Quarantine, for comparing a pair of my specimens with the types of *T. pygmaea* and for the loan of a pair of paratypes of that species, by means of which

I was able to corroborate his conclusions as to the identity of the two supposed species.

*Male*.—Mesonotum shining black only posteriorly, laterally, and on and near humeri, otherwise densely brown pollinose except for two distinct whitish longitudinal vittae; from posterior view the brownish pollen appears golden brown, with some lavender intermixed; mesonotal pile mostly long, whitish, with some fine black pile interspersed. Scutellum silvery-pollinose except at base. Abdomen black, for the most part densely silvery-pollinose, sides of second to fifth segments inclusively shining on anterior half or more of the segments laterally; sterna except first subshining basally. Ninth tergum blackish, the lateral lobes acute, becoming yellowish-red toward apices; ninth sternum broadly divided into two acute lobes which become yellowish-red toward apices; genitalia otherwise reddish-yellow; outer forceps (fig. 3) large, the apical part broadened, a small black thorn-like protuberance near the upper anterior corner; pile of ninth segment mostly as on pregenital segments, but a few black setulae on the tergum and some long slender black and whitish bristles on the sternum; outer forceps with a tuft of yellow hairs at upper posterior corner, otherwise with mostly black and a few yellow hairs. Length, 6-7 mm.

*Female*.—Mesonotal pollen except laterally and on the two longitudinal vittae wine-red to lavender, the color evident only from a posterior view. Length, 6-8.5 mm.

*Material studied*.—Irish Canyon, south of Sparks, Moffat County, Colorado, June 25, 1946 (M. T. James), 8 males, 6 females; Phillipsburg, Jefferson County, Colorado, July 3, 1947 (James), 1 male.

#### KEY TO THE MALES OF THE *T. pygmaea* GROUP

1. Wing with two brown cross-bands.....*anomala* Adams  
Wing hyaline.....2
2. Abdomen with shining areas laterally on each of segments two to five; front legs wholly black.....*pygmaea* Cole  
Abdomen entirely gray or whitish-pollinose laterally; front tibia yellow at least basally.....3
3. Mesonotal pile in part black; wing veins black.....*melanoneura* Loew  
Mesonotal pile wholly pale; wing veins yellow toward base. .*xanthobasis*, n. sp.

INTRODUCTION TO APPLIED ENTOMOLOGY, by WILLIAM J. BAERG.  
vii+191 pages, 208 figures. Burgess Publishing Co., Minneapolis 15,  
Minnesota. 3rd revised edition. 1948. Price, \$4.00.

The primary objective in Baerg's recent edition is "to acquaint the student with the more common insects, some spiders and scorpions, as well as a few mites and ticks." A relatively thorough discussion is presented on the various classes of arthropods, which is too often slighted in similar texts. The insects under discussion are discussed according to their systematic position, rather than by crops or hosts. The advisability of such an arrangement is always debatable.

In view of the recent advances in insecticides, perhaps more emphasis should be placed on the newer compounds. The illustrations for the most part are good. Recent or more important references on the economic pests treated are listed. Certainly, this work will be well received by instructors charged with the teaching of general courses in economic entomology.—H. S. TELFORD.

## AN INSECT RESPIROMETER

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In the course of some studies on house flies, it became desirable to determine the respiratory exchange of individuals. Since the metabolism of such insects is low, a fairly sensitive apparatus was required. Existing micro-respirometers were not well adapted for use with whole active insects, consequently the apparatus described herein was constructed.

### APPARATUS

The constant pressure principle was adopted as the basis for this respirometer, shown in figure 1, as it permitted simple construction and operation. It is similar to the apparatus of Kalmus (1928) except that the size is greater. The apparatus was constructed from a brass block, as were the differential or Barcroft type respirometers of Cunningham and Kirk (1940), Barth and Kirk (1942), and Crisp and Thorpe (1947). This construction is advantageous since the low heat capacity and high conductivity practically eliminate zonal temperatures.

Round stock was used in making this model; however the shape of the block is not critical. A flat surface,  $1\frac{1}{4}$  inch wide, was machined on the bar, and five wells,  $\frac{1}{2}$  inch in diameter and  $\frac{1}{2}$  inch deep, drilled through this surface. These served as the respiration chambers. Smaller wells,  $\frac{1}{4}$  inch in diameter, were drilled perpendicular to the first set to hold the index capillaries. Small holes,  $\frac{1}{8}$  inch in diameter, connect the respiration chamber and index capillaries.

The  $\frac{1}{4}$  inch wells were threaded to accommodate brass sleeves into which the index capillaries were sealed with tempered shellac. This arrangement held the capillaries rigidly and still permitted them to be exchanged for others. Where a capillary was not level when installed, it was adjusted in place by bending the glass after it had been heated with a hand torch. It was also found adequate to seat the capillaries directly into the respirometer block. In this case, rubber bands were used to hold the tube against lightly greased rubber gaskets. A support was required at the distal ends of the capillaries to keep them level.

Index capillaries were prepared from ordinary thick walled stock of the appropriate diameter (0.3–1.0 mm.). The distal end was blown out and fire polished to facilitate insertion of an oil index droplet. The capillaries were calibrated with mercury, and the bore checked as to uniformity by measuring the length of the mercury droplet at several points. The volume calibration is most conveniently expressed as  $\lambda$  /cm. ( $1\lambda = 1$  microliter = 1 cubic millimeter) and may be used directly

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as a volume factor in calculations. A reading scale made of millimeter paper was attached to each tube by means of "Scotch Tape."

The screens separating the insect from the hydroxide were made of 70 mesh brass, and were mounted on rings cut from ( $\frac{1}{2}$  inch) copper tubing. Large squares of screen were "tacked" to the ring with solder, then trimmed with a motor driven wire wheel. This not only removed excess screen, but also fused the brass and copper. Excess solder was removed by heating in a flame and shaking it out.

Hydroxide holders were prepared by closing and flattening one end of a piece of glass tubing of the proper diameter (5–10 mm.) and cutting it at the appropriate length. These holders could all be adjusted to the same glass volume by adding or removing glass to bring them to the same

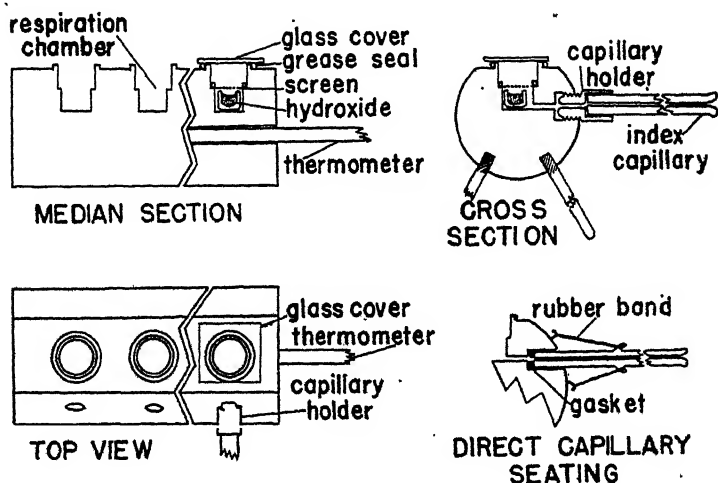


FIG. 1. Construction details of an insect respirometer.

weight. A standard amount of 10% sodium hydroxide was pipetted into each holder to absorb the carbon dioxide.

Glass covers used for the individual chambers were cut from microscope slides. These permitted observation of the test material and the grease seal. Since glass has a low heat conductivity, heat transfer through the cover was negligible. Covers were sealed to the block with petrolatum which was applied with a Luer syringe. A thick layer was applied outside the chamber rim, thus when the cover was in place, none of the grease entered the chamber.

Temperature of the block was measured with a thermometer which was inserted in a hole drilled horizontally. Thermoregulation could be established by either an air or water thermostat. In the latter case, only the lower part of the block was immersed. In most cases, however, ordinary room conditions were sufficiently stable to permit satisfactory determinations, provided the temperature was at the desired level. Metabolic effects of temperature differences are correctable by thermal coefficients which can be calculated after a few trials at different tem-

peratures. In the case of flies, these factors may be taken from the work of Batelli and Stern which has been summarized by Wigglesworth (1939).

#### PROCEDURE

Prior to a trial, the assembled respirometer was equilibrated with the environment for a period of an hour. Flies were chilled at 4°C, which rendered them comatose and easy to handle. This could be accomplished either by placing a cage of flies in a cold room, or by catching a few in a test tube and immersing it in ice-water. For metabolic studies, this method is superior to treatment with ether or other chemicals where residues of the anaesthetic may have a physiological effect.

Individual flies were weighed to 0.2 mg. (on a Roller-Smith torsion balance) and installed in their respective respiration chambers. One chamber was left as a blank or thermobarometer, and used to correct observed results for barometric and thermal changes. The rims of the chambers were then greased and covers put in place. The gas composition in the respiration chamber can be changed by directing a stream of the desired gas (oxygen for example) into the chamber during the closing process.

When the chambers had been closed, the index oil droplet was installed with a finely drawn pipette. Kerosene was used for this purpose, being treated as recommended by Schmitt (1933) to remove resinous residues. The drop could be placed directly in the calibrated portion of the capillary, or it could be drawn in from the end after briefly touching the cover glass with a hot object (such as the glowing end of a cigarette). In cases where the respiratory exchange was rapid, such adjustment was unnecessary except in the thermobarometer. Proper sealing of the individual chambers was tested either by pressing on the cover glass or by blowing sharply toward the open end of the capillary. In a satisfactory preparation the droplet is displaced, but readily returns to its original position.

Readings of the index droplet position were started ten or fifteen minutes after the assembly of the apparatus, and were continued at fifteen minute intervals. A total period of one hour was usually sufficient for a trial. Interruption of the trial to treat the insects was readily accomplished. The adult animals were caught in a test tube which was held over the mouth of the chamber as the cover was removed. The tube, plugged with cotton, was then immersed in ice water to immobilize the insect.

At the termination of the trial the insects were removed and the apparatus cleaned. If the animals had been treated with any toxic material (such as DDT) residues were removed with an appropriate solvent. Between trials, the apparatus should be stored in such a position as to permit drainage of the capillaries.

#### CALCULATIONS

Calculation of the volume of oxygen consumed is simple, since it is proportional to the displacement of the index droplet after it has been corrected for thermal and barometric changes. The thermobarometer

correction is most conveniently made on a linear basis. This results in an error when there are cross-sectional differences between the capillaries. When the thermobarometer change is relatively small, however, this error is negligible. For example, the inaccuracy from this short-cut would be only 1% when the respiration change is tenfold greater than the thermobarometer change, even though the capillary volume factors may differ as much as 10%. When the thermobarometer change is relatively great, however, it should be multiplied by the ratio of the

TABLE I  
TRIAL WITH HOUSE FLY LARVAE (26 SEPT., 1947)

Chamber No.	Droplet Position (cm.) at indicated time				Droplet Displacement (cm.) (corrected with thermobarometer)			
	1530	1545	1600	1645	¼ hr.	¼ hr.	¼ hr.	av.
1	0.70	1.34	1.90	2.47	0.77	0.69	0.64	0.70
2	1.07	1.90	2.69	3.46	0.95	0.92	0.85	0.91
3	1.73	1.60	1.47	1.40	(thermobarometer)			
4	0.75	0.80	0.92	0.97	0.18	0.25	0.12	0.18
5	1.00	3.28	5.00	6.48	2.41	1.85	1.55	1.94
t (°C.)	28.00	28.02	28.08	28.10				

Chamber No.	Volume Factor (λ/cm.)	Oxygen Cons. * (λ/hr.)	Larval Weight (mg.)	Q' O <sub>2</sub> * (λ/mg./hr.)
1	6.0	14.6	10.0	1.5
2	6.5	20.6	10.5	2.0
4	6.0	3.7	11.0	0.4
5	6.6	44.5	25.8	1.7

(\*Calculated to standard conditions.)

Barometer: 762 mm. Hg.

Conversion factor (to standard conditions): 0.87.

thermobarometer capillary volume factor to that of the respiration capillary before being used as a correction.

The formula for calculating the gas volume change in a respiration chamber is as follows:

$$(\text{cm. respiratory change} - \text{cm. thermobarometer change}) \\ \times \text{volume factor} = \text{oxygen consumption}$$

The volume of oxygen consumed can be reduced subsequently to standard conditions (dry, 0°C., 760 mm. Hg. pressure) according to the gas laws. For this calculation, the gas may be considered as saturated with water vapor.

The protocol of an actual trial with house fly larvae is given in table I. The increased oxygen consumption noted in the first period is a result of increased activity of the animal. It is absent with pupae and more pronounced with adults. It can be reduced by lengthening

the preliminary period. The larva in chamber 4 was in a pre-pupal stage, which accounts for the low rate of oxygen consumption observed. These data are in agreement with those of Batelli and Stern, who found the oxygen consumption of fly larva at 28°C. to be  $2 \lambda \text{ O}_2/\text{mg.}$ , hr. and of fly pupa,  $0.1 \lambda \text{ O}_2/\text{mg.}/\text{hr.}$

#### DISCUSSION

The apparatus described furnishes a rapid and simple means of determining the respiratory exchange of insects. It has been found convenient and useful in physiological studies of insects. Its design is such that its fabrication is inexpensive. The theoretical basis of this (constant pressure) type of respirometer is the simplest of manometric respirometers (Dixon, 1943). With the index drop directly measuring the volume change, this apparatus is well suited to studying insects of house fly size. For much smaller measurements, a more sensitive apparatus, such as the differential respirometers previously mentioned, is preferable. For much larger measurements, a more elaborate system of carbon dioxide absorption and volume measurement is required, simple diffusion and capillary volumes no longer being sufficient. On the present scale, carbon dioxide absorption is rapid and adequate. This is tested roughly by exhaling into a chamber, after which it is sealed and absorption followed by means of the index drop. The process is completed in about thirty seconds.

As has been previously noted, volumetric calibration of the chambers is unnecessary. In some cases, however, where differences in chamber volumes exist, and environmental conditions cause large thermobarometer changes, the chamber volume must be taken into consideration. Such differences can be detected by a test trial in which all chambers are thermobarometers. Observed differences may be corrected during calculation, or by changing the volume of the chamber. This latter step may be done empirically by adding paraffin to the chamber. It might be noted that the volumetric change resulting from the presence of a 20 mg. fly in a 2 ml. chamber is only 1%.

#### SUMMARY

An apparatus for measuring the oxygen consumption of insects (house fly size) is described. The protocol of a trial is included.

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# A STUDY OF THE MORPHOLOGY OF THE IMMATURE STAGES OF *Aedes trivittatus* (COQUILLET)

(Diptera: Culicidae)<sup>1</sup>

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## INTRODUCTION

The breeding habits of the various species of mosquitoes and the character and amount of precipitation are so variable that it often happens that all larvae collected at a particular time are immature, or that immature larvae of one or more species are associated with mature larvae or all developmental stages of other species; so the values of being able to recognize the immature larvae at the time of collection are obvious.

Since (1917), when Howard, Dyar and Knab first described the fourth stage larva of numerous species including that of *Aedes trivittatus*, subsequent authors followed in almost the same line, until Dodge (1945), realizing the very little attention given to the early larval instars, studied and made keys to the first stage larvae of 59 North American species of mosquitoes, including a brief description of *Aedes trivittatus*. He concluded that specific and generic differences are as well marked in the first instar as in the fourth, and the same characters used in determining fourth stage larvae may apply to the first instar. Abdel-Malek and Goulding (1948) put emphasis on the value of using the head capsule widths, the length of the air siphons, or both these characteristics in combination, as criteria for determination of the larval instars of four species of mosquitoes, namely: *Aedes aegypti*, *Aedes trivittatus*, *Culex apicalis* and *Anopheles quadrimaculatus*.

*Aedes trivittatus* (Coq.) breeds in open sites where temporary pools are apt to be formed by rain or flood. *Aedes vexans* and *Psorophora ferox* are almost always associated with *Aedes trivittatus* wherever the latter is found in its breeding sites. This paper deals with the morphology of the immature stages of this species.

## MORPHOLOGY OF THE IMMATURE STAGES

### *Egg Stage*

(Plate I, fig. 1)

On an average the egg is 0.574 mm. long by 0.178 mm. wide. The egg is fusiform in shape. The whole of the external surface of the egg is sculptured into large and small lens-shaped bosses, which form a polygonal pattern. The ventral side of the egg is a little flatter than the dorsal side. The color is white when laid and changes to jet black within a few hours.

<sup>1</sup>Contribution from the Department of Zoology and Entomology.



*First Stage Larva*

(Plate I)

The length of the larva in this stage varies from 2.4 to 4.3 mm. with an average length of 3.7 mm. The average head width and length of the air siphon are 0.312 mm. and 0.286 mm. respectively.

The head is broader than long and is formed as in the case of the rest of the larval instars of four sclerotized plates. These are (a) the frontoclypeus, occupying the greater part of the dorsal surface of the head capsule; (b) a pair of epicranial plates forming the lateral and most of the ventral surface of the capsule; (c) the gula, a more or less small inverted V-shaped ventral sclerite extending from the base of the labium to the occipital foramen and is defined laterally by the gular sutures, from which arise a pair of gular apodemes.

Anteriorly, the fronto-clypeus has a narrow forward extension, the preclypeus, carrying the labrum.

On both sides of the head, there is a pair of eyes situated medio-laterally on the epicranial plates. Each eye is in the form of a small, more or less oval, pinkish area with a number of dark spots.

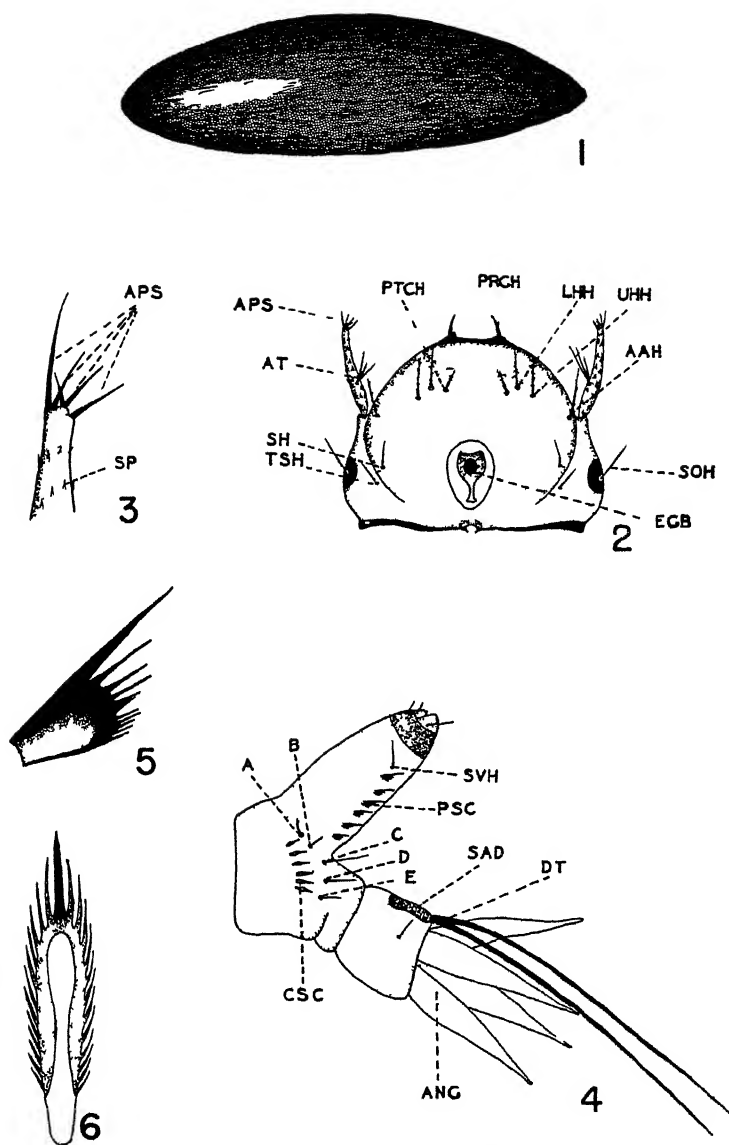
The antennae arise from the epicranial plates near the right and left extremities of the epicranial suture. Each antenna is less than half as long as the head and is slender and slightly tapering to the apex. The antennal shaft is studded with numerous forwardly pointing spinules arranged in a more or less oblique row. Projecting from the posterior one-third of the dorsal side of the antenna is the antennal hair which is trifid and with the individual branches reaching more or less the anterior fourth of the antenna. The anterior extremity of the antenna (Fig. 3) is truncate and carries four long slender spines and one short stout spine less than one-fourth of the length of the long spines.

The head carries a number of symmetrically arranged paired simple hairs which are in approximately the same positions as those in the fourth stage except that the upper head hairs (UHH) are not in line with the lower head hairs (LHH), but are more outwardly placed. In addition to the above hairs, there is a pair of long, stout, and more or less spine-like hairs on the preclypeus known as the preclypeal hairs (PRCH). On both sides of the dorsomeson and more or less in a horizontal line with the lower head hairs is a pair of moderately short hairs known as the posterior clypeal hairs (PTCH). A pair of single barbed long hairs known as the ante-antennal hairs (AAH) are situated on the fronto-clypeus near the insertion of the antennae.

On both sides of the epicranial suture between the eyes and the egg-breaker, there are two pairs of hairs, the sutural hairs (SH) and the trans-sutural hairs (TSH); the former are situated anterior to the latter. Centrally located in each eye is a simple long hair known as the supra-orbital hair (SOH).

On the frontoclypeus, midway between the eyes, is a fairly large oval depression in which is situated the egg-breaker (EGB) (Fig. 2) which is a brownish club-shaped plate with a median very strongly chitinized dark cone.

The upper lateral abdominal hairs are double on the first three segments and single on the remainder. The lateral comb of the eighth



# PLATE I

*Aedes trivittatus* (Coquillett), egg and first stage larva Fig 1 Egg  
Fig 2 Head, dorsal aspect Fig 3 Extremity of antenna Fig 4 Eighth  
and ninth abdominal segments Fig 5 Pecten scale Fig 6 Lateral comb  
scale

segment is formed of five to six fairly large scales in an even row. Each individual scale (Fig. 6) is elongate thorn-shaped with a fairly long spine at the apex, about one-third the length of the body of the scale. Along the sides of the scale there are delicate fairly long hairs. Posterior to each comb along the distal margin of the eighth segment there is a group of five simple and long hairs, called the pentad hairs by Dodge (1945). These hairs were designated by Greek symbols by Marshall (1938), but the writer prefers the Arabic designations adopted by Hearle (1929) and Dodge (1945), thus labeling them A, B, C, D, and E (Fig. 4).

The eighth abdominal segment carries dorsally the breathing tube or air siphon. It is cylindrical in shape with a slight constriction near the apex. It is about three times as long as wide with the apical one-sixth well sclerotized and brownish in color. The siphon carries a pair of ventrolateral rows of detached flattened scales, each row being known as a pecten. The pecten (Fig. 4) is formed of six to seven widely separated scales (PSC) reaching beyond the middle of the siphon length. Each individual scale (Fig. 5) is more or less triangular in outline and produced at one side into six to seven spines, the distal one being the longest and the remainder progressively shorter towards the base of the scale.

The saddle of the ninth segment is narrow, well sclerotized, and more or less oval in outline. It covers the dorsal posterior half of the segment and reaches only a very short way down the sides of the ninth segment. Subdorsally on each side of the posterior third of the ninth segment there is a long delicate hair.

On the posterior dorsal end of the ninth segment there are four long, stout hairs forming the dorsal tuft (DT). There is no ventral tuft in this stage.

The four anal gills (ANG) are long and pointed with a length approximately four times that of the saddle.

The general color of the larva in this stage is brownish-white with the head capsule and other sclerotized parts brownish.

### *Second Stage Larva*

(Plate II)

The length of the larva in this stage varies from 2.43 to 4.14 mm. with an average length of 3.1 mm. The average width of the head capsule and length of the air siphon are 0.550 mm. and 0.479 mm. respectively.

The head in this stage is broader posteriorly than in the first instar. The eyes resemble those of the first instar except being somewhat bigger. The antennae are broadened towards the base and are slightly curved inwards. The anterior extremity of the antenna carries one long slender appendage and four shorter stout ones, one of which is truncate. The antennal tuft (Fig. 7) is usually bifid and arises from nearly the posterior third of the antenna. The hairs of the antennal tuft do not reach the anterior end of the antenna.

The head capsule hairs are in the same positions as in the first instar except that the upper head hairs are situated slightly inwards to the lower head pair. Both the upper and lower head hairs are sparsely barbed. The ante-antennal hair is formed of three barbed branches and reach nearly the antennal hair tuft.

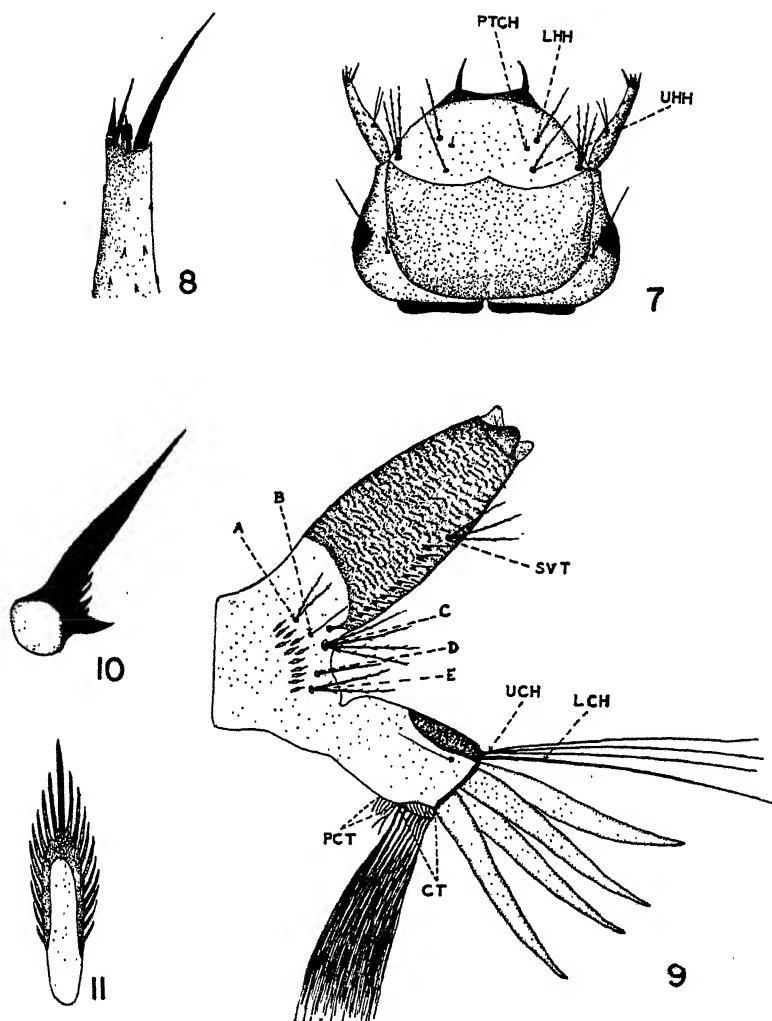


PLATE II

*Aedes trivittatus* (Coquillett), second stage larva. Fig. 7. Head, dorsal aspect. Fig. 8. Extremity of antenna. Fig. 9. Eighth and ninth abdominal segments. Fig. 10. Pecten scale. Fig. 11. Lateral comb scale.

All the hairs, other than the upper, lower and ante-antennal hairs, are much reduced in length. The transsutural hair has two to three branches and the supraorbital hair is simple (Fig. 7).

The egg breaker is lost in this stage. The upper lateral abdominal hairs are double on the first abdominal segment only and single on the remainder.

The lateral comb of the eighth segment is formed of eight to twelve scales arranged in a triangular patch of two irregular rows. Each individual scale (Fig. 11) has a stout apical spine about half as long as the body of the scale. On both sides, the scale is fringed with delicate hairs. The pentad hairs (Fig. 9) situated posterior to the lateral comb are in the same positions as those of the first instar, but are different in being longer and some of them are branched. The A hair has two barbed branches, the B hair is simple, the C hair with three to four barbed branches, the D hair is simple, and the E hair has two barbed branches.

The air siphon is conical in shape, with the broadest portion near the basal one-third. The siphon is about two times long as wide and with the apical four-fifths well sclerotized and light brownish in color. The pecten is formed of eight to twelve uniformly spaced scales reaching a little beyond the middle of the siphon. Each pecten scale (Fig. 10) is formed of a long apical tooth or rarely sometimes two, followed by from five to six shorter teeth. Each pecten is followed by a three branched hair tuft, the subventral hair tuft (SVT) the branches of which are barbed.

The saddle covers nearly two-thirds of the dorsal surface of the ninth segment and reaches about one-fifth down the sides of the segment. Both the saddle and the siphon are well sclerotized and with many minute spinules over their surfaces arranged in alternate transverse rows. Laterally, on both sides of the posterior one-third of the ninth segment, there is a pair of long delicate single hairs. The dorsal brush arises from the dorsoapical angle of the anal segment and is composed of a pair of upper caudal hairs (UCH) each being three-branched; and a pair of long and single lower caudal hairs (LCH). The ventroapical margin of the ninth segment has a ventral brush formed of two portions: the cratal tuft (CT) posteriorly, formed of eight branched hairs arising from the barred area, and a precratal tuft (PCT) arising anterior to the barred area and formed of seven hairs all of which are simple except the one close to the cratal tuft being bifid. The precratal tuft extends from the proximal end of the cratal tuft to nearly the middle of the ninth segment.

The anal gills are four in number, long tapering and about three times the length of the saddle.

The color of the larva in this stage is brownish white, but darker than the first instar and with two brownish ribbons extending on both sides of the dorsomeson from the posterior half of the thorax to the base of the air siphon.

### *Third Stage Larva*

(Plate III)

The length of the larva in this stage varies from 3.33 to 5.4 mm. with an average length of 4.59 mm. The average width of the head capsule and length of the air siphon are 0.827 mm. and 0.667 mm. respectively.

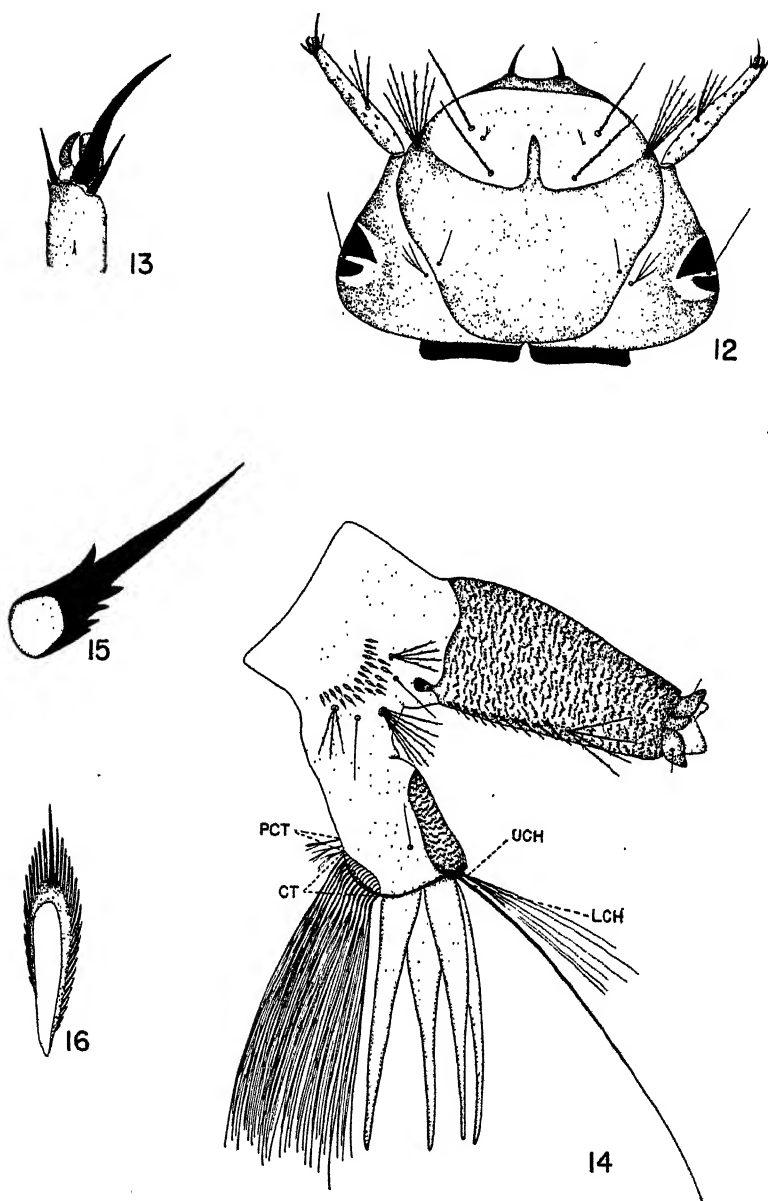


PLATE III

*Aedes trivittatus* (Coquillett), third stage larva. Fig. 12. Head, dorsal aspect. Fig. 13. Extremity of antenna. Fig. 14. Eighth and ninth abdominal segments. Fig. 15. Pecten scale. Fig. 16. Lateral comb scale.

The head is broader in this stage than in the second instar. The eyes are in the form of a pair of dark patches situated mediolaterally on each side of the head capsule. The additional eye on each side is in the form of a crescent-shaped dark patch of a larger size than the patch originally present in the first and second instars and is situated in front of the latter patch. This anterior patch was considered by Howard, Dyar and Knab (1912) and Marshall (1938) to represent the slowly developing compound eyes of the future adult, showing through the larval skin. The antennae are more or less cylindrical, being only slightly broadened toward their middle length. Apically, each antenna carries five appendages (Fig. 13), a long spine, two short delicate spines, one short stout spine, and a short broad cylindrical appendage. From nearly the middle of the spinulated shaft, arises the antennal tuft (Fig. 12) formed of three hairs not reaching the anterior end of the antenna.

The head hairs (Fig. 12) are in the same positions as in the second instar. The lower and upper head hairs are single and sparsely barbed, the ante-antennal tuft with five to seven barbed hairs; the post clypeal hair short, delicate, and three branched; the sutural hair single; and the transsutural with two to four delicate branches. The supraorbital hair is simple, long, and situated on the upper inner angle of the posterior eye patch.

The upper lateral abdominal hairs are double on the first two abdominal segments and single on the remainder. The lateral comb of the eighth segment is in the form of a large triangular patch of from 19 to 28 scales with an average of 23 scales arranged in three irregular rows. The scales are fairly large, each has a stout apical spine about half as long as the body of the scale. Each scale (Fig. 16) is fringed on both sides with delicate long spines diminishing gradually in length towards the base of the scale. The pentad hairs (Fig. 14) on the posterior margin of the eighth segment vary in branching from those of the second instar. The A hair tuft is three- to four-branched, the B hair is single, the C hair tuft with six to seven branches, the D hair is single and the E hair tuft is two- to three-branched. The hair branches of the tufts A, C, and E are barbed.

The anal siphon is conical in shape. It is nearly twice as long as wide with the widest portion near its middle. Approximately the apical five-sixths of the siphon is well sclerotized and brown in color. The pecten is formed of 11 to 13 equally spaced scales occupying nearly the basal half of the siphon length. Each pecten is followed by a three- to four-branched long hair tuft, the branches of which are barbed. Each individual pecten scale (Fig. 15) has a long apical spine and a varying number of short teeth which may amount to five teeth.

The saddle on the dorsal side of the ninth abdominal segment reaches in this instar about one-fourth down the sides of the segment.

Over the surface of both the siphon and the saddle, there are numerous well sclerotized spinules arranged in alternate transverse rows. The lateral hair of the ninth segment is in the same position as that of the second instar. Each of the upper caudal hairs of the dorsal brush is six-branched, while the pair of lower caudal hairs are long and single. The cratal tuft (CT) of the ventral brush is formed of thirteen branched

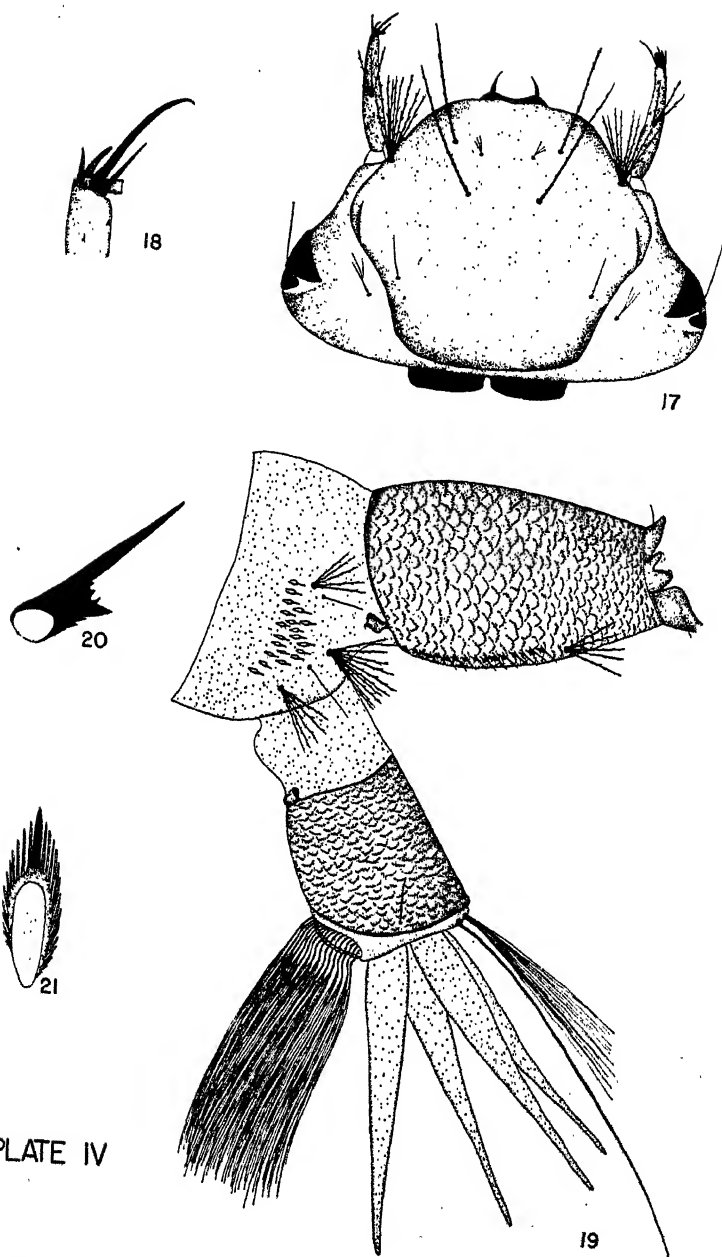


PLATE IV

*Aedes trivittatus* (Coquillett), fourth stage larva. Fig. 17. Head, dorsal aspect. Fig. 18. Extremity of antenna. Fig. 19. Eighth and ninth abdominal segments. Fig. 20. Pecten scale. Fig. 21. Lateral comb scale.



hairs, each arising from the barred area and five-branched. The precratral tuft (PCT) is formed of three to four branched small delicate hairs. The anal gills are four in number, conical, tapering apically and about two times the length of the saddle.

The color of the larva in this stage is brownish white, with two brownish ribbons, extending from the middle of the thorax to the base of the siphon along the dorsomeson, more broader than in the case of the second instar.

#### *Fourth Stage Larva*

(Plate IV)

The length of the larva at this stage varies from 5.04 to 6.57 mm. with an average length of 6.1 mm. The average width of the head capsule and length of the anal siphon are 1.10 mm. and 0.81 mm. respectively.

The head in this stage is markedly broader than long with the broadest portion basal to the eyes from which the head capsule slopes regularly to the front end. The eyes, as in the case of the third instar, are in the form of two pairs of dark brown patches, situated medio-laterally on both sides of the head capsule. The anterior patch is crescent shaped, nearly four times the size of the posterior patch which is oval in outline.

The antennae are more or less cylindrical with the anterior half slightly curved inwards. The antennae, as in all the larval instars, are studded with numerous forwardly pointing spines. The antennal tuft is inserted near the middle of the shaft and formed of three barbed hairs not reaching the anterior end of the shaft. The anterior end of the antenna (Fig. 18) is truncate and carries five appendages: one stout and long, two shorter and delicate, one short and stout, and a short cylindrical truncate appendage.

The head hairs are in the same positions as in the second and third instars. The upper and lower head hairs are long, single, and sparsely barbed. The ante-antennal hair tuft has eight to nine barbed hairs. The postclypeal hair is short, delicate, and three-branched. The sutural hair is single, the transsutural with three branches. The supraorbital hair is simple, long, and situated on the upper inner angle of the posterior eye patch.

The upper lateral abdominal hairs are double on the first two abdominal segments and single on the rest. The lateral comb of the eighth abdominal segment is in a triangular patch formed of 19 to 28 scales with an average of 22 scales arranged in three irregular rows. Each individual scale (Fig. 21) has a broad apical spine nearly as long as the body of the scale which is fringed on both sides with long delicate subapical spinules. The pentad hairs vary in branching from those of the third instar: The A hair is four- to six-branched, the B hair is single, the C hair with 8 to 13 branches, the D hair is single, and the E hair is four- to six-branched. All the pentad hairs except B and D are barbed.

The anal siphon (Fig. 19) is conical in shape, about twice as long as wide with the widest portion near its middle length. The anal siphon is well sclerotized and light brown in color.

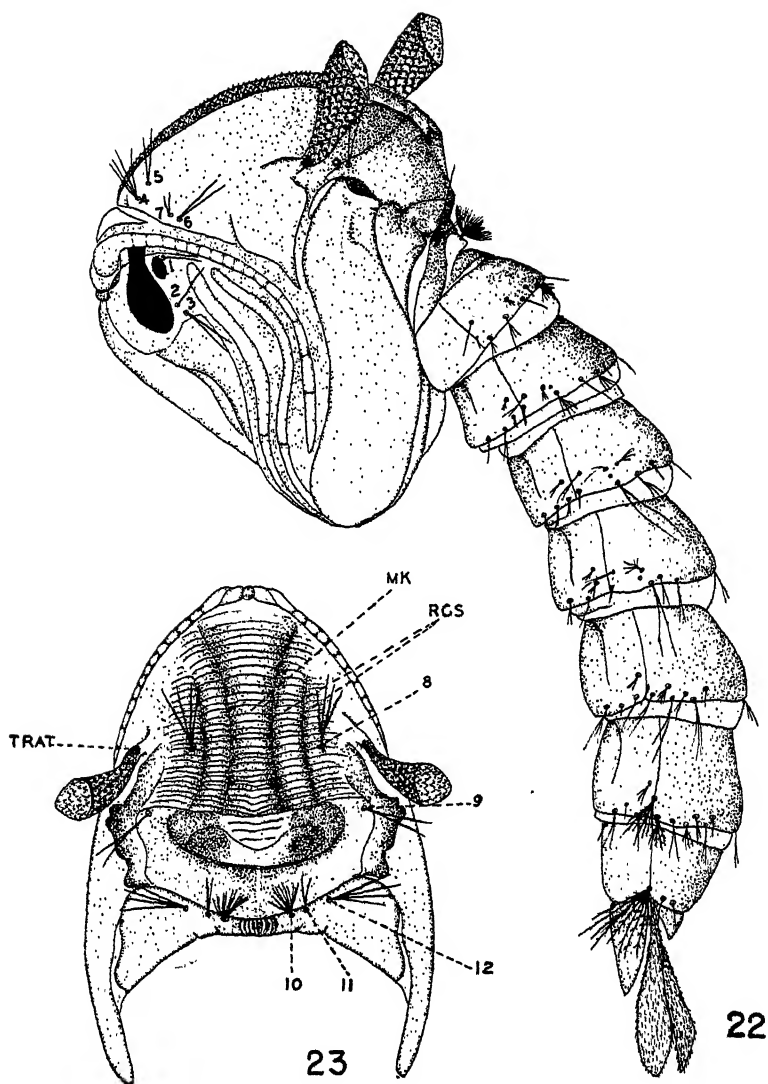


PLATE V

*Aedes trivittatus* (Coquillett), pupa. Fig. 22. Lateral aspect. Fig. 23. Cephalothorax, dorsal aspect.

TABLE I  
SUMMARY OF THE NUMERICAL VALUES OBSERVED IN *Aedes trivittatus* (Coq.) IN THE FOUR LARVAL INSTARS

INSTAR	NUMBER OF LARVAE EXAMINED	LENGTH OF LARVA			WIDTH OF HEAD CAPSULE			LENGTH OF ANAL SIPHON			NUMBER OF COMB SCALES			NUMBER OF PECTEN SCALES		
		Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.
1st	30	2.16	1.21	1.85	0.360	0.225	0.312	0.36	0.225	0.286	6	5	5.76	6	5	5.63
2nd	35	4.14	2.43	3.10	0.63	0.45	0.55	0.54	0.45	0.479	12	8	11.45	11	8	9.68
3rd	23	5.4	3.33	4.59	0.90	0.72	0.827	0.81	0.58	0.667	28	19	22.48	13	10	11.96
4th	10	6.57	5.04	6.10	1.17	1.08	1.107	0.90	0.81	0.814	28	19	21.9	17	15	15.8

The pecten is formed of 15 to 17 equally spaced scales occupying nearly the basal half of the anal siphon. Each pecten is followed by a tuft of four to five hairs known as the subventral tuft. Each individual pecten scale (Fig. 20) has a long apical spine and from five to eight short basal ventral teeth. The ninth abdominal segment is longer than wide with the saddle surrounding completely its posterior three-fifths. The skin of the body is smooth without spinules except on both the saddle and siphon where there are numerous spinules arranged in alternate transverse rows.

The lateral hair on both sides of the ninth abdominal segment is single and delicate and in the same position as that of the third instar.

The dorsal brush is formed of a pair of long unbranched caudal hairs and a pair of shorter multiple-branched upper caudal hairs. The ventral brush is formed of 16 multiple-branched hairs arising from the barred area and forming the cratal tuft. The precratal tuft is absent in this stage.

The anal gills are four in number, long, tapering, and about two times the length of the saddle.

The color of the larva is similar to that of the third instar.

A summary of all the numerical values observed in all the four larval instars of *Aedes trivittatus* is represented in Table I.

### *Pupa* (Plate V)

The pupa, as usual in all mosquitoes, is comma-shaped with the head of the comma representing the cephalothorax and the tail the pupal abdomen. The most noticeable feature of the cephalothorax is the compound eye of the future adult which shows conspicuously through the integument. The eye is accompanied by the small oval pupal eye. Among other visible contents of the cephalothorax, are a number of flexible, chitinous sheaths, within which the mouth parts, antennae, legs, wings and other appendages of the future adult are located. The respiratory trumpets are narrow at their bases and are distally divergent. They are dark brown in color with a length of about 0.67 mm. on the average. According to Macfie and Ingram (1920) the respiratory trumpet can be regarded as divisible into a closed tubular portion called the meatus, and an open portion called the pinna. In *Aedes trivittatus* there is a small definite tracheoid area at the base of the meatus. The ratio of the length of the meatus to the total length of the respiratory trumpet is about 1 : 1.43. The whole surface of each trumpet is covered with a fine network carrying a great number of short curved spinules.

The dorsal surface of the cephalothorax (Fig. 23) bears two pairs of prominent ridges (RGS) on both sides of a strong median very noticeable keel; this median keel (MK), along which the skin splits when the imago emerges, is provided with a variable number of strong transverse ribs extending all the way through the ridges.

The arrangement of the cephalothoracic setae appears to be similar to those in *Aedes aegypti* (Macfie 1919). There are twelve pairs of setae in all; three on the head shield, called the postocular (1-3); four near the front margin of the thorax, called the anterothoracic (4-7); one on the dorsal surface of the thorax near the trumpets, called the dorsal

seta (8); one supraalar (9) at the base of the wing case, and three posterior-thoracic (10-12) on the metanotal plate.

*The postocular setae.* These are composed of: (a) *the upper postocular seta* (1), long, delicate, and situated posterior to the upper posterior angle of the eye; (b) *the median postocular seta* (2), delicate, small, and situated behind the eye near its lower margin; (c) *the lower postocular seta* (3), of moderate length, delicate, and situated posterior to the median seta and a little outer to it. Both the median and lower post ocular setae may be single or double.

*The anterothoracic setae.* These are composed of: (a) *the lower anterior seta* (4), of moderate length, situated a little above the antennae, and divided into four or five branches; (b) *the upper anterior seta* (5), delicate, of moderate length, situated above and slightly posterior to the lower anterior seta, and either two or three-branched; (c) *the lower posterior seta* (6), stouter and longer than the preceding, situated just close to the upper margin of the antenna above the eye, and two-branched; (d) *the upper posterior seta* (7), stout and short, situated close to and a little anterior to the lower posterior seta; it may be bifid.

*The dorsal seta* (8) is a delicate, rather long seta situated on the thorax a little posterior and internal to the respiratory trumpets. It may be four or five-branched.

*The supraalar seta* (9) is a moderately long, delicate seta situated on the thorax above the roots of the wing. It may be two or three-branched.

*The posterior thoracic setae.* These are moderately well developed and formed of three setae: (a) *the internal seta* (10), of moderate size and eight or nine-branched; (b) *the median seta* (11), stouter and longer than the internal seta and two-branched; (c) *the external seta* (12), of moderate length, stout, and may be four-branched.

### *Pupal Abdomen*

(Plate VI)

The abdomen of the pupa is composed of nine segments, the terminal of which is much smaller than any of the other segments. The terminal segment carries a pair of more or less pyriform large paddles (PD). The length of the paddle is about 1.078 mm. and the ratio of its length to the greatest breadth is about 1.5 to 1. The midrib is moderately developed, highly sclerotized and does not reach the distal end of the paddle. The paddles are fringed by minute denticles which also cover their whole surfaces. The terminal seta is situated a bit outside an imaginary line from the midrib to the distal end of the paddle. The terminal seta is about one-sixth the length of the paddle (i.e. about 0.182 mm.) and is single, not branched.

The first eight segments of the pupal abdomen carry, both dorsally, and some of them ventrally, various paired hairs or setae.

### *The Dorsal Abdominal Setae*

(Fig. 24)

On each abdominal segment except the last, there are normally eight or nine dorsal setae on each side. The terminology of the setae used in this description are those adopted by Baisas (1938) in his description of the chaetotaxy of the culicine pupal abdomen. Baisas has adopted

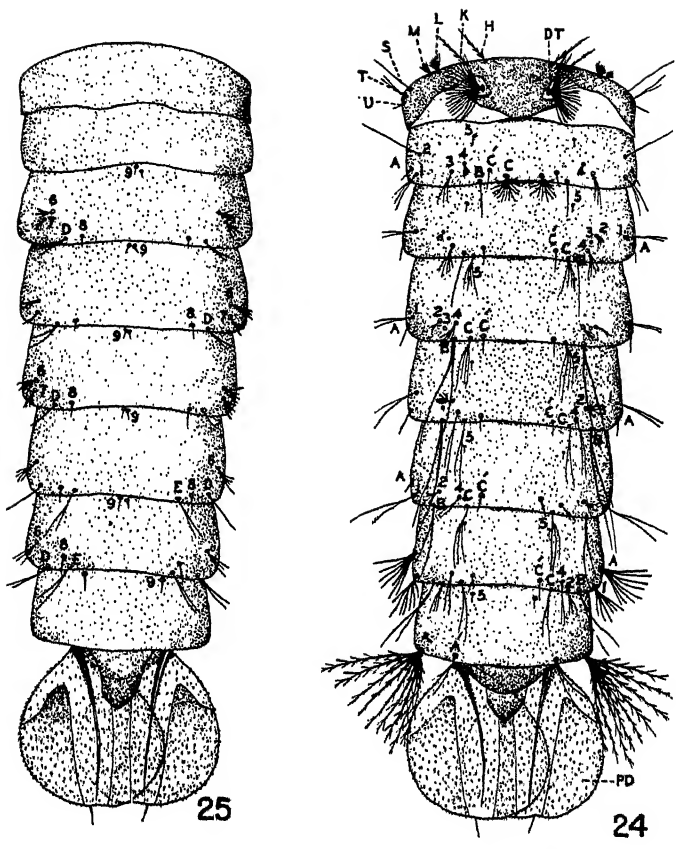


PLATE VI

*Aedes trivittatus* (Coquillett), pupal abdomen. Fig. 24. Dorsal abdominal setae. Fig. 25. Ventral abdominal setae.

with some modification, the system proposed by Macfie (1919) and developed by Senevet (1936).

The seta on segments II to VII can be homologized without great difficulty and are designated A, B, C, C', 1, 2, 3, 4, and 5. Seta A is very small on all the segments except those on segments VII and VIII where they become large and tuft-like and a bit removed from the posterior corner of the segment. It is ventrolateral in position rather than dorsal. Setae B and C are the largest setae on the posterior margin of the segment.

Seta C' varies in position with respect to C on the different segments. In general it is well removed from the posterior margin and is internal to C in all the segments except the second, where it is external to C.

Seta 1 is the next largest after B and C. It is situated close to the lateral margin and not far from the posterior margin of each segment.

Seta 2, 3, and 4 are small setae lying somewhat anterior to B and C. On segments three to five seta 3 is represented by a small socket without any seta, while on segments six to eight it is absent.

Seta 5 is minute and placed near the anterior border of the segment.

On the first abdominal segment, the setae are also eight in number on each side, but their arrangement is entirely different and they were given a different terminology by Baisas (1938). The most conspicuous is a large tuft near the middle of the segment, which usually has been spoken of as, the dentritic tuft or float-hair as applied by Edwards (1941). It is regarded as being homologous to seta C of the succeeding segments. The remaining setae of the first abdominal segment are four near the anterior border designated H, K, L, and M, and three on the lateral border designated S, T, and U.

On the eighth segment there are only three dorsal setae on each side, designated by Baisas, as A, A' and 5 where A is in the form of a tuft on the posterior corner of the segment, A' is on the posterior margin and moderately long and delicate, and 5 is near the base of the segment.

The ninth segment is without setae.

Details regarding the characteristics and sub-divisions of the dorsal abdominal setae are furnished in the following table.

Segment	Seta	Description of Seta
I	Dentritic tuft	Large, well developed, with 16 to 17 strong primary branches, with all the hairs barbed.
	H	Moderately long, stout, barbed seta, situated immediately anterior to the dentritic tuft and directed forwards.
	K	Long, stout, barbed seta, situated near seta H, but a little external and posterior to the latter. It is also directed forwards and may be single or terminally bifid.
	L	A small tuft of about eight hairs, situated nearly in a transverse line with seta H, about halfway between the latter and the lateral margin of the segment. It is directed forwards and outwards.
	M	A small tuft of about six hairs situated close to seta L but slightly anterior and external to the latter. It is directed forwards and outwards.
	S	Very long, strong, barbed seta, situated on the lateral anterior margin of the segment.
	T	Rather long seta, but not as long as seta S. It has two to three branches and is situated close to and external to seta S. It is directed outwards and forwards.

Segment	Seta	Description of Seta
	U	Small, delicate seta, situated on the border of the segment, external to seta T. Its end may be divided into two branches.
II	A	Small, rather stout.
	1	Rather long, delicate, three-branched, and situated posterior to A.
	2	Long, stout, seta, situated internal and anterior to A.
	3	Rather long, delicate, three-branched seta, situated midway between one and four.
	4	A small tuft of six to eight hairs situated outer and anterior to B.
	B	Rather long, stout, single seta near the posterior border of the segment.
	C'	Stout, single seta, equal in length to B, and situated slightly anterior and internal to the latter.
	C	Rather long tuft of 18 to 20 hairs situated near the posterior border at the middle of the segment.
	5	Minute single seta.
III	A	Small, rather stout, situated latero-ventrally.
	1	Rather long, delicate, two-branched, and situated latero-dorsally, somewhat anterior and internal to the insertion of A.
	2	A small tuft of four to five hairs.
	3	Represented by a small socket without a seta and situated more or less posterior and internal to 2.
	4	Moderately long, delicate, four- to five-branched seta, situated posterior to and inner to seta 3.
	B	Very long, stout, seta, reaching the posterior end of Segment IV.
	C	Rather long, delicate, four- to five-branched seta.
	C'	Small, stout seta situated internal and anterior to C.
	5	Minute.
IV	A	Small, rather stout.
	1	Rather long, delicate, two-branched.
	2	Small, delicate, one- to two-branched.
	3	Represented by a small socket without a seta and is situated posterior and internal to 2.
	4	Longer than seta 2, delicate, five-branched and situated internal and anterior to both setae 2 and 3.
	5	Very long, stout, two-branched seta, reaching the mid-length of segment VI.
	C	Long, delicate, two- to three-branched, reaching about the posterior third of segment V.
	C'	Small, stout, seta, anterior and internal to C.
	5	Minute.
V	A	Small, rather stout.
	1	Long, delicate, two-branched.
	2	Rather long, delicate, six- to seven-branched, situated anterior and more or less internal to B.
	3	Represented by a socket only, situated anterior to seta B.
	4	Long, delicate, two-branched, situated posterior and internal to seta 3.
	B	Very long, stout, two-branched, reaching beyond the posterior end of the sixth segment.
	C	Long, delicate, two-branched, reaching the posterior one-third of segment VI.
	C'	Small, stout seta, situated anterior and internal to seta C.
	5	Minute.



Segment	Seta	Description of Seta
VI	A	Small, rather stout.
	1	Long, delicate, two-branched.
	2	Rather long, five-branched tuft, situated anterior and more or less internal to seta B.
	3	Missing.
	4	Long, delicate, two-branched, far removed from seta 2, and situated anterior and more or less outer to seta C.
	B	Very long, stout, two-branched seta, reaching nearly the mid-length of the VII segment.
VII	C	Long, delicate, three-branched seta, reaching the posterior one-third of the seventh segment.
	C'	Small, stout seta, situated anterior and internal to seta C.
	5	Minute.
	A	Rather long tuft of six or seven strong hairs.
	1	Smaller tuft than A, consisting of six or seven strong hairs, situated posterior and inner to the insertion of A.
	2	Rather long, delicate, three-branched, situated internal and posterior to seta B.
VIII	3	Missing.
	4	Rather stout, two-branched seta, situated anterior and internal to seta 2.
	B	Rather stout, long, two-branched seta reaching nearly the posterior one-third of the eighth segment.
	C	Long, delicate, two-branched seta, reaching nearly the posterior end of the eighth segment.
	C'	Small, stout seta, situated anterior and internal to seta C.
	5	Minute.

### Ventral Abdominal Setae

(Fig. 25)

The setae on the ventral aspect of the abdomen are few and relatively inconspicuous. The following setae as given by Baisas (1938) may be recognized on each side of the abdomen on segments three to eight.

(a) *The mediolateral seta* (6), a little internal to the lateral border and rather posterior to the middle of the segment.

(b) *The posterolateral seta* (7), in a lateral position, internal to the posterior angle of the segment.

(c) *The inner ventral seta* (8), situated near the posterior margin of the segment, midway between the middle and the posterior angle of the segment.

(d) *The outer ventral seta* (D), situated near the posterior margin of the segment between the inner ventral seta and the posterolateral seta.

(e) *The anterior ventrocentral seta* (9), situated at the anterior margin of the segment and very close to the ventromeson.

The first and second abdominal segments possess no ventral setae. Setae D, 6 and 8 are present in segments three to seven; seta 7 in segments three to five; seta E in segments six to seven; and seta 9 is present in segments three to eight. On the eighth abdominal segment setae 9 are not close together as is the case in all the other anterior segments, but are widely separated and lie near the anterior margin of the eighth

segment a little internal to the level of insertion of setae E on the seventh segment.

The ventral abdominal setae are described in the following table.

Segment	Seta	Description of Seta
III	6	Small delicate tuft of four or five hairs.
	7	Small delicate tuft of five or six hairs.
	D	Rather long, delicate, two-branched hair.
	8	Small, single, delicate hair.
	9	Minute.
IV	6	Small, delicate, three-branched hair.
	7	Small, delicate, two-branched hair, longer than seta 6.
	D	Long, delicate, two-branched hair.
	8	Small, single, delicate hair.
	9	Minute.
V	6	Small delicate tuft of four hairs.
	7	Small tuft of five or six hairs, longer than seta 6.
	D	Long delicate single hair.
	8	Small delicate one or two-branched hair.
	9	Minute.
VI	6	Small delicate three-branched hair.
	7	Missing.
	D	Long delicate single hair.
	8	Small single hair situated anterior and outer to E.
	E	Long delicate two-branched hair.
VII	6	Small, delicate, two- to three-branched hair.
	7	Missing.
	D	Long, delicate, two-branched hair.
	8	Small single hair situated anterior and outer to E.
	E	Long, delicate, two-branched hair.
VIII	9	Minute.

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# THE BIOLOGY AND THE IMMATURE STAGES OF THE MOSQUITO, *MEGARHINUS SEPTENTRIONALIS* DYAR & KNAB<sup>1, 3</sup>

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## INTRODUCTION

There is some confusion in the literature regarding the date and place of publication of the original description of *Megarhinus septentrionalis*, and the relationship of this name to *M. herricki* Theobald, the latter now being accepted as a synonym of *M. septentrionalis*. In most publications dealing with the taxonomy of this species, authors have referred to an article by Dyar and Knab, 1907, Jour. N. Y. Ent. Soc. 15: 12, as the place of the original description. In this paper, however, the authors do not describe the species, but indicate that the original description was made in a previous article: Smithsonian Misc. Coll. 48: 249, 1906. The original description is indeed published in this article. Although the date of volume 48 of the Smithsonian Miscellaneous Collections in 1907, the paper in question was actually published in September, 1906. The name *Megarhinus herricki* was given to this same species by Theobald in 1906 (The Entomologist 29: 241), but this publication appeared in November, and this gives a slight priority to the name *M. septentrionalis* D. & K. Although Dyar in his monograph "The Mosquitoes of the Americas" (1928) refers to the article in the Journal of the New York Entomological Society as the place of the original description of the species, future workers should cite the Smithsonian publication to avoid further confusion.

Some workers (Jenkins and Carpenter, 1946) regard *septentrionalis* as a subspecies of *M. rutulis*. According to these workers, a study of larval features of both groups indicates that they are identical. The only known distinction between the adults is a slight difference in coloration of certain tarsal segments in the males. These men have studied series of males and state that even this distinction shows intergradation in areas where the two groups overlap.

*Megarhinus septentrionalis* is one of the largest mosquitoes in the United States, but the adults do not bite. Observations have confirmed that both males and females of several species of the genus feed upon flower nectar and possibly other plant juices (Knab, 1907, 1911). The larvae are carnivorous, and they have been seen to feed upon the larvae of other mosquitoes. The eggs are usually deposited

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<sup>2</sup>The writer greatly appreciates the assistance of Mrs. Sarah Martin who made the drawings, and Dr. Robert Matheson and Mr. Curtis W. Sabrosky who aided in determining the place and date of the original description of the mosquito.

<sup>3</sup>Since this paper was submitted for publication, it has been found that the name *Toxorhynchites* Theobald has priority over *Megarhinus* Robineau-Desvoidy.

in tree holes containing water, but larvae have been collected occasionally from water in artificial containers.

This mosquito is now known to occur generally over the eastern and southeastern United States from New Jersey and Northern Florida, west to central Kansas and Texas (Jenkins and Carpenter, 1946). In some parts of its range, it has been reported as passing the winter in the larval stage.

#### THE PRESENT STUDY

The writer and his associates have been collecting tree hole breeding mosquitoes in central Texas for the past two years. Most intensive work has been done in the vicinity of Austin, but other collections have been made at Palmetto State Park near Luling, and at Round Rock, Stephenville, Bartlett, Marquez and Fredericksburg, Texas.

Eggs and larvae of *M. septentrionalis* in various instars have been obtained. Larvae, either collected from the field or hatched from eggs, were isolated in small staining dishes containing tree hole water, and reared in the laboratory. No attempt was made to control the laboratory temperature, but since most of the work was done in the spring and summer, the laboratory temperature was probably comparable to outside temperature, except that at night the former was probably somewhat higher. Living larvae were studied under a dissecting binocular microscope. Some larvae were mounted on slides, while the skins of those reared to maturity were preserved for study. The larvae were kept constantly supplied with food in the form of tree hole mosquito larvae, and adult and larval *Drosophila* or fruit flies, the latter being kindly furnished by the geneticists of the Department of Zoology.

More than 30 early larval instars were studied in this work, all collected near Austin, Texas. Of this number, 10 were reared successfully from the egg stage, while 7 others were reared from young instars collected in the field. The additional specimens either were mounted for study, or died before they emerged as adults. In addition, a large number of fourth stage larvae collected in nature from several localities have been studied and observed in the laboratory. Larger series of early instars collected from distant localities may show some variations from the structures and reactions observed by the writer.

#### GENERAL BIOLOGY

*Megarhinus septentrionalis* probably passes the winter as an adult in this area. Numerous collections have been made during the winters of 1946-47 and 1947-48, and although other species of tree hole breeding mosquitoes were frequently found, no larvae of this species have been collected before April.

On April 3, 1947, the writer discovered a large number of eggs of this species in a cavity in a live oak tree (*Quercus virginiana*). While preparations were being made to collect the eggs, a female *Megarhinus* flew to the opening, and disregarding the writer whose head was within a yard of the tree hole, dipped up and down above the water surface. These movements continued for approximately a minute, during which time the insect was humming audibly, the sound being loudest as the mosquito attained a position closest to the water. The insect was

captured as it rested on the tree trunk after it had finished its aerial "dance." It is thought probable that the mosquito was ovipositing during this flight, but since a number of previously deposited eggs were on the water surface, this could not be determined positively. This method of oviposition has been suggested for other species of *Megarhinus* (Howard, Dyar and Knab, 1912; Jenkins and Carpenter, 1946).

As indicated above, the *Megarhinus* larvae were fed on mosquito larvae and larval and adult fruit flies. All the first group of larvae that were obtained from eggs were started on mosquito larvae, but after a week or so, the supply of mosquito larvae could not be maintained and fruit flies were used as substitute food for some of the mosquitoes.

Morgan and Cotton (1908) report that *Megarhinus* larvae do not actively hunt their food, and that they will attack other mosquito larvae only if the other larvae bump into them or come quite close. This method of feeding is apparently generally accepted by most workers, and the mosquitoes used by the writer reacted in this way when mosquito and fruit fly larvae were used. But when adult fruit flies were placed on the water surface, a very interesting reaction was observed in the *Megarhinus* larvae under some conditions. Fruit flies placed on the surface usually start struggling to escape. These movements caused no reactions from the mosquito larvae if they were beneath the surface. But when the siphons of the larvae were in contact with the surface film, the insects were almost immediately attracted by the struggles of the flies. If the heads of the larvae were directed toward the flies, they would start swimming at once toward the insects. Otherwise, the mosquito larva would swing its body about toward the disturbance before swimming to the fly. Once a larva was under a struggling fly, it would seize a portion of the fly's body, and with a quick flip, attempt to drag it beneath the surface. Sometimes the mosquito would be successful at the first trial, but in the case of larger flies, the film of air about the body made it necessary for the larva to try several times before it was successful. Several times a mosquito larva struck at a fruit fly on the surface, but did not succeed in seizing it. The striking movement carried the mosquito beneath the water surface. In such instances, the mosquito frequently returned to the surface and struck again even though the siphon was at that time out of contact with the surface film. In some cases the complete fly was eaten, while in others, a few parts such as the wings were rejected. Light was not of any apparent significance in these reactions, since larvae in darkness caught flies as readily as did those exposed to the light of the laboratory.

Tests showed that a struggling fruit fly would attract the *Megarhinus* larvae as far away as  $1\frac{1}{2}$  inches, but small adults at least did not cause any reactions at a greater distance than this. Occasionally the mosquito larvae were not attracted to the adult fruit flies, even though their siphons were in contact with the surface film. However, tests at later dates did cause reactions in most individuals.

All reared larvae progressed rapidly to the fourth instar whether fed mosquito larvae, fruit flies or both. After the fourth instar was

attained, however, the developmental rate differed greatly depending upon the type of food that was used. All specimens reared from the egg stage preferred adult fruit flies to mosquito larvae in the fourth instar, and they would frequently eat fruit flies when mosquito larvae were totally disregarded. Larvae that were reared entirely on *Drosophila* (larvae during the early instars and adults later), or those that were fed adult fruit flies during the last instars, passed from egg to adult in from 25 to 35 days. No larvae fed entirely on mosquito larvae were reared to adults. They attained the fourth instar and remained in this stage as long as several months, or until fed adult fruit flies.

It seems probable that the length of the fourth larval instar was dependent, in part at least, upon the amount of food consumed by the

TABLE I  
LARVAE FED ADULT DROSOPHILA IN LATE INSTARS

Larva	Egg Hatched	Became 4th Instar	Pupated	Emerged
1	April 4	April 18	April 28	May 3
2	April 4	April 17	May 4	May 8
3	April 4	April 20	May 4	May 8
4	April 14	April 26	May 5	May 9
5	April 14	April 30	May 6	May 11

TABLE II  
LARVAE REARED TO FOURTH INSTAR ON MOSQUITO LARVAE

Larva	Egg Hatched	Became 4th Instar	Adult Fruit Flies Fed	Pupated	Emerged
1	April 4	April 15	May 31	June 5	June 9
2	April 4	April 15	June 19	June 25	June 29
3	April 4	April 15	Aug. 8	Aug. 28	Sept. 2

larvae. Although the insects were kept continuously supplied with mosquito larvae, they would frequently disregard this potential food for two or three days. Several *Megarhinus* larvae averaged eating approximately one mosquito larva every two days over a period of several weeks, while others, fed on adult *Drosophila*, often ate several flies daily. Fruit flies reared on specially prepared food may, of course, contain elements not found in mosquito larvae, and these substances may have influenced the appetites and speeded the metamorphosis of the *Megarhinus* larvae.

Several larvae were reared to fourth instar using mosquito larvae only, and then were taken at intervals and fed adult fruit flies. These larvae later pupated and emerged as adults. Accurate records were kept on several specimens using both types of food. Those in Table I were fed adult *Drosophila* during the late instars, while those in Table II

were kept supplied with mosquito larvae only until the date indicated in the table.

These observations indicate that in nature adult insects that disturb the surface film may form a larger percentage of the diet of *Megarhinus* larvae than formerly thought. Fourth stage larvae collected in the field and exposed to adult fruit flies in the laboratory reacted just as vigorously as did laboratory reared specimens. It is doubtful, however, that these larvae are of much importance in destroying freshly emerged adult mosquitoes, or those that happen to alight on the surface. All such adult mosquitoes that have been observed by the writer have not moved about to any extent, and *Megarhinus* larvae have never been seen to attack anything that was not actively moving at the time. Newly emerged adults of *Orthopodomyia signifera* and *Aedes triseriatus* have been seen resting on a water surface without attracting the attention of *Megarhinus* larvae that were in the water.

It is well known that the mouth brushes of *Megarhinus* larvae are modified into relatively large hook-like structures, and it has been stated frequently that the larvae use these brushes to seize and hold the prey during feeding. The writer has not determined if this action has actually been observed, or if this is only an assumption based upon the structure of the modified brushes. The writer has frequently watched *Megarhinus* larvae under a binocular dissecting microscope seize mosquito larvae and adult fruit flies, and the feeding process has been observed. In all cases the mandibles alone were used, and the employment of the brushes has never been seen. However, it is possible that the proper functioning of the mandibles is dependent in some way upon these brushes. In two cases fourth stage larvae apparently received an injury to the mouth brushes, since the structures were not folded against the sides of the head as usual, but extended laterally at an angle. Both these larvae tried time and again to seize mosquito larvae and fruit flies, but they were never successful and eventually they died.

#### THE IMMATURE STAGES

*The Egg*.—The eggs of this species (text fig. 1) have been observed and briefly described by several workers. They are pure white, oval in shape and the surface is studded with small tubercles. It has been suggested that the white color is caused by air bubbles, but this is not the case, since material scraped from the surface remains as a white deposit after it has dried.

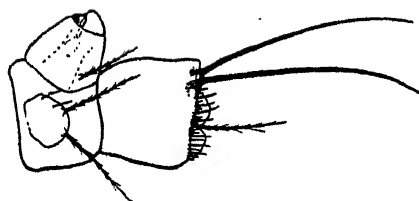
The eggs float high on the water surface, and they are very difficult to work with. If one tries to pick up an egg with a pipette, several attempts must usually be made before the worker is successful, since the egg frequently slides along the surface film if disturbed. Once an egg has been caught within a pipette, care must still be exerted in putting it into a container. Several eggs were lost because they bounced from the water surface and out of the staining dish into which they were being placed. The bouncing characteristic of the eggs is probably correlated with the oviposition habits of the adults; that is assuming that the females actually do oviposit as they dip up and down above the water—a habit generally accepted by most workers. In many instances

the female is not directly above the water when she deposits the eggs, but if the eggs were expelled with some force, they could conceivably strike the sides of the tree hole and bounce down into the water. The female observed by the writer that was probably ovipositing, dipped up and down at the outer opening of the cavity, and was never directly over the water which was several inches back from the opening.

Eggs brought into the laboratory hatched within 24 to 48 hours after having been collected. Although the eggs are not immersed in water, some contact with water or at least a high humidity is necessary for their survival since they disintegrate if allowed to dry.



1



2

FIG. 1. Egg of *Megarhinus septentrionalis* D. & K.

FIG. 2. Posterior segments of first stage larva of *Megarhinus septentrionalis* D. & K.

In the discussion of the larval instars to follow, only those structures are emphasized that are of importance in distinguishing the different stages.

*First Larval Instar:*—The hatching process has not been seen, but several specimens have been observed a short time after hatching. The larvae are at first semi-transparent and white except for the mandibles, eyes, the so-called egg burster near the center of the head and a few splotches of brown scattered over the thorax and abdomen. Within 24 hours, however, the head, siphon and anal segment have become a dark brown color, and sclerotic areas from which groups



of hairs arise have become evident over the thorax and abdomen. Thoracic and abdominal hairs are similar to the condition found in later instars, but the hairs are somewhat longer compared with the width of the body.

Unless disturbed, the larvae have a tendency for a time to remain at the surface. They lie almost parallel with the surface, probably because of the very short siphon, and they may easily be mistaken for *Anopheles* upon casual examination. When moving from one place to another the larvae have a tendency to "crawl" along the surface film using the siphon to push themselves forward, sometimes accompanied by slight wiggling movements.

Larvae only a few hours old feed readily, and they are not adverse to attacking larvae several times their own bulk. On several occasions, second and third stage larvae of *Aedes triseriatus* have been seized by recently hatched *Megarhinus* larvae and overcome, despite the furious struggles of the victim. In most cases, larvae of this size were only partially eaten. Cannibalism was observed once or twice before specimens were segregated, but they did not seem to be as much attracted to their fellows as to other species of larvae. Several times, the larvae were seen to bump into each other with no reaction from either party, while on one occasion three *Megarhinus* larvae fed peacefully upon a larva of *A. triseriatus*.

The most striking differences between the first and succeeding instars occur in the posterior abdominal segments (text fig. 2). No ventral brush is present, and the dorsal brush consists of four hairs, two on each side. The siphonal hair or subventral tuft is a single barbed hair. The siphon is much shorter, compared with the ninth or anal segment, than in other instars.

*Second Larval Instar:*—A ventral brush appears in the second instar (Plate I, fig. 1). The dorsal brush consists of two tufts of hairs on each side, the upper of which usually has three or four branches, while the lower has two. The siphonal hair is still a single barbed hair.

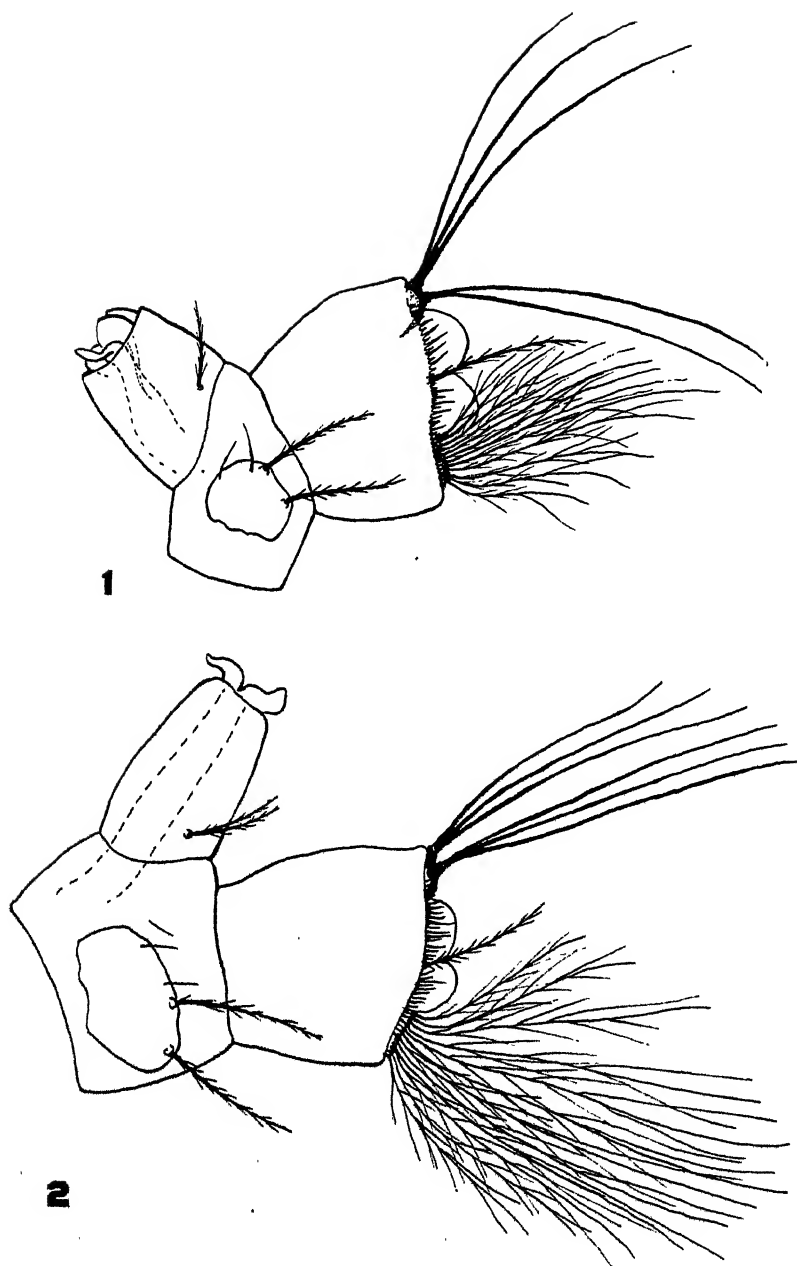
*Third Larval Instar:*—The upper tuft of the dorsal brush in the third instar may have from three to five branches on each side, while the lower tuft has three (Plate I, fig. 2). The siphonal hair has now become a tuft with two to three branches. The ventral brush is similar to that of the second instar.

*Fourth Larval Instar:*—The upper tuft of the dorsal brush has from five to eight branches on each side (text fig. 3). The lower tuft usually has four branches, but may occasionally have five. The siphonal hair is now a multiple tuft with many branches, while the ventral brush is similar to that of the second and third instars.

Fourth stage larvae differ from the other instars in the structure of the mouth brushes. In all instars except the last, each mouth brush has several small teeth on the end, but no teeth occur in the fourth although each brush has a rather sharp curved point.

It should be noted that each instar can usually be identified by the number of branches in the lower tuft of the dorsal brush. As a rule, there is a single branch on each side in the first instar, two branches in the second, three in the third and four or five branches in the fourth.

Neither ecdysis nor pupation have ever been observed, but both



Posterior segments of larvae of *Megarhinus septentrionalis* D. & K.  
Fig. 1. Second instar. Fig. 2. Third instar.

processes must be quite rapid. On several occasions larvae have been examined at intervals for long periods in an attempt to see actual ecdysis or pupation. In several instances, a specimen has been examined as a normal larva, and less than ten minutes later a subsequent observation showed that ecdysis or pupation had occurred. Fourth stage larvae within a few hours of pupation can be identified. The thorax of the larva becomes semi-transparent along the sides and some of the pupal structures can be seen through the pupal skin.

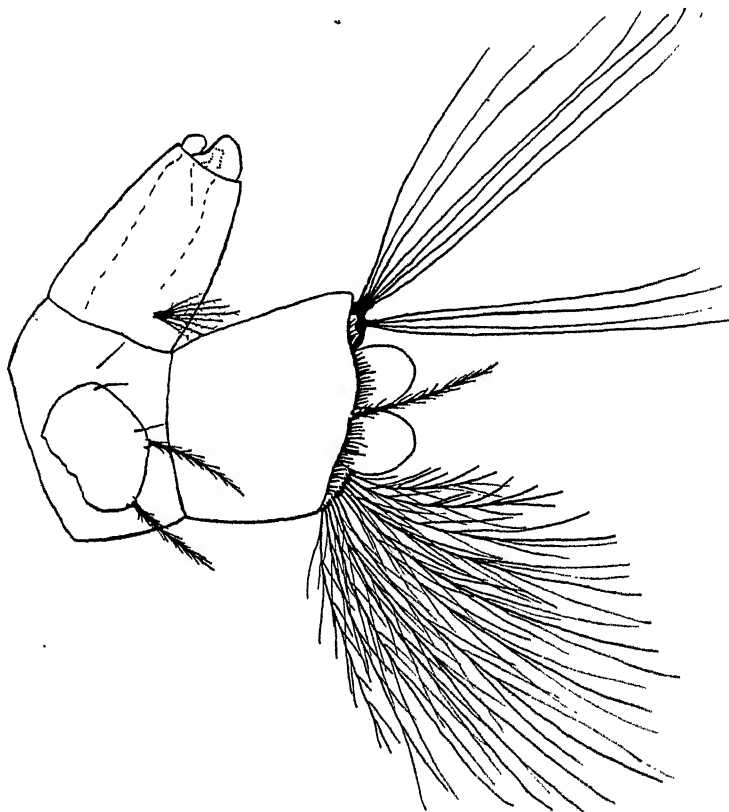


FIG. 3. Posterior segments of fourth stage larva of *Megarhinus septentrionalis* D. & K.

#### SUMMARY

1. Observations have been made upon specimens of the mosquito, *Megarhinus septentrionalis* D. & K. reared from egg to adult. Possible oviposition of a female is described.

2. Larvae were fed other mosquito larvae, and larval and adult fruit flies. Fourth stage larvae exhibited a decided preference for adult fruit flies, and the use of adult fruit flies was necessary before the larvae would pupate.

3. The modified mouth brushes of *Megarhinus* larvae have previously been assumed to be used for capturing and holding prey. Observations of the feeding process have failed to confirm this, and consequently the previously accepted function of these mouth brushes is questioned.

4. Characteristics of the eggs are described, and distinguishing features of the four larval instars are discussed.

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THE CORIXIDAE OF THE WESTERN HEMISPHERE, by H. B. HUNGERFORD.  
Univ. Kansas Sci. Bul. 32: 1-827, 112 plates, 19 text figures. 1948.

The identification of the American Corixidae which in the author's words "has been a difficult and discouraging task for many years," should be greatly facilitated by this monograph. In it, Dr. Hungerford has included, under one cover, a comprehensive treatment of the family as it occurs in the Americas, with keys, descriptions, distributional data, information as to the location of types, and some biological information. One color plate, photographs, half-tones, line-drawings, and distributional maps of the individual species, constitute the illustrations. Most of the work is original, although the author has, for the sake of completeness, included keys, descriptions, and plates from Deay's revision of the genus *Tenagobia*, and Sailer's previously unpublished monograph of *Trichocorixa* (pp. 289-407) is included. This treatment has led to certain inconsistencies of style, but the user of the work should not find these troublesome. A new subfamily classification is proposed, with six subfamilies of the world, three of which are new. A new tribal classification is likewise proposed for the Corixinae. In all, 209 species, of which 51 are new, and 12 subspecies, of which 9 are new, are discussed.

Special mention might be given to the series of wash drawings, Plates IV to VIII inclusively, which illustrate the genera and subgenera of the world. These immediately follow the key to the subfamilies, and would have been still more useful if the subfamily and tribal designations of the genera had been included in the legends. The discussion of techniques of study and of preparation of genitalia, the latter particularly well outlined by Dr. Sailer (pp. 300-301), should be very useful. Finally, Dr. Hungerford's discussion of corixid systematics and of generic concepts may be read with profit by any taxonomist.—M. T. J.

## FIVE NEW BUPRESTIDAE FROM SOUTH TEXAS (COLEOPTERA)<sup>1</sup>

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The following Buprestidae were collected while the writer was stationed in South Texas with the U. S. Public Health Service. Throughout the preparation of this paper the invaluable guidance given by Mr. W. S. Fisher is gratefully acknowledged. The writer also is indebted for the privilege of studying the extensive collections of Buprestidae in the U. S. National Museum. Dr. J. N. Knull has kindly compared a number of the specimens with types in his collection.

### *Chrysobothris pubilineata* n. sp.

Figs. 1-6

*Male*.—Form and size of *cupreohumeralis* Van Dyke; head brassy green becoming bronzy black at occiput; pronotum bronzy black; elytra bronzy brown, with a broad area bright red cuperous along the lateral margins, and each elytron with moderately long recumbent whitish pubescence arranged in five narrow but rather distinct lineae; surface beneath bronzy black and almost obscured with white pubescence and efflorescence; legs bronzy black.

Head with front rather flat, somewhat densely hairy, granulose, and coarsely but shallowly and uniformly punctate; antennae bronzy black, gradually narrowed to apex, and barely extending to middle of pronotum when laid along side margin.

Pronotum twice as wide as long, somewhat wider at base than at apex, and widest at basal third; sides arcuately rounded; disc convex and without median depression; surface coarsely, somewhat densely punctate, moderately clothed with rather long recumbent whitish hairs, especially at the sides, and the intervals rather finely granulose. Scutellum triangular, granulose.

Elytra slightly wider than pronotum; sides nearly parallel from humeral angles to apical third, then narrowed to rounded apices; lateral margins finely serrate; basal and humeral depressions distinct; disc moderately convex, without discal foveae; surface densely coarsely punctate.

Prosternum sparsely coarsely punctate and rather densely clothed with long recumbent hairs; anterior margin with a broad short lobe. Anterior femur with a distinct tooth.

Length, 6.25 mm.; width, 2.48 mm. Paratype length, 5.97 mm.; width, 2.30 mm.

*Female*.—Differs from the male in having the front of head black with a slight bluish tinge, and in having the last visible abdominal sternite broadly rounded at apex.

<sup>1</sup>Scientific Article A208. Contribution No. 2125 of the Maryland Agricultural Experiment Station (Department of Entomology).

Length, 6.54 mm.; width, 2.56 mm.

*Type locality*.—Starr County, Texas; 6½ miles southeast of Rio Grande City, beside the highway leading to Mission, Texas.

*Type material*.—Described from two male and one female specimens collected on living *Acacia rigidula* Benth. at the above locality April 12, and 19, 1947. Male type deposited in the U. S. National Museum (No. 58836); allotype and male paratype are in the writer's collection.

*Comparison*.—This abundantly distinct species runs to *lixa* Horn by Fisher's key<sup>2</sup> since it bears a tooth on the anterior femora. However, it otherwise seems to be closer to *cupreohumeralis* Van Dyke and *ephedrae* Knull, from which it may be readily recognized by the lines of pubescence on the elytra.

***Agrilus exsapindi* n. sp.**

Fig. 7

*Male*.—Form of *obsoletoguttatus* Gory; head bronzy green to brassy green; pronotum and elytra varying from olivaceous cupreous to brownish cupreous and each elytron ornamented, vaguely, with yellowish pubescent spots, one in basal depression, one at basal third, an elongate one at apical third, and another at the apex, the latter two vaguely connected in better marked specimens; beneath more shining and the sides mostly covered with yellowish pubescence and efflorescence.

Head with front somewhat narrow, feebly convex, about equal in width from top to bottom, and with median groove feebly indicated; surface granulose, densely coarsely punctate, and sparsely clothed with recumbent yellowish pubescence; antennae extending to posterior angles of pronotum when laid along sides, and serrate from the fourth joint with the outer segments much longer than wide.

Pronotum broader than long, about as wide at base as at apex, widest near apex, sides obliquely narrowed from apex to behind middle then more strongly narrowed to base, the angle being quadrate; marginal and submarginal carinae sinuate, broadly separated at middle and connected at basal fourth; basal margin with median lobe deeply emarginate; disc convex, with two distinct median impressions and a broad oblique depression on each side, prehumeral carinae prominent, straight; surface rugose with sides near margins densely covered with pubescence and efflorescence. Scutellum transversely carinate.

Elytra slightly wider than pronotum at base; vaguely broadly constricted in front of middle, scarcely expanded posteriorly, with tips rounded separately and strongly serrulate; sides of abdomen narrowly exposed, anterior half covered with pubescence and efflorescence; disc flattened, each elytron with a rather distinct longitudinal costa and basal depressions; surface coarsely, irregularly, imbricate punctate and uniformly clothed with short recumbent yellowish pubescence.

Abdomen beneath finely sparsely, punctate, with rather long sparse recumbent pubescence, and with sides of the two basal segments and a large spot on the side of each of the remaining three segments densely clothed with recumbent yellowish pubescence and efflorescence; first two ventrals without median impression and with suture unindicated

<sup>2</sup>W. S. Fisher, U. S. Department of Agriculture Miscellaneous Publication No. 470, pp. 1-275, 1942.

at the sides; pygidium carinate, the carina not projecting. Sides of thorax densely covered with yellowish white pubescence and efflorescence; prosternal lobe shallowly emarginate. Tarsal claws simply cleft, with inner lobes of hind claws shorter and broader; tibiae straight.

Length, 7.88 mm; width, 1.68 mm.

*Female*.—Distinguished from the male in having the front and clypeus cupreous black and not granulose, in having the elytral markings more distinct, and in being more robust.

Length, 8.80 mm; width, 2.12 mm.

*Type locality*.—S. W. Hidalgo County, Texas; one mile south of Granjeno.

*Type material*.—Described from 24 male and 36 female specimens. Almost half of these were reared from a log of *Sapindus Drummondii* H. and A. and the others were collected on succulent foliage of this tree; March 29 through September 16, 1947. Type and four paratypes deposited in the U. S. National Museum (No. 58837); paratypes also deposited in the collections of the American Museum of Natural History and of J. N. Knull; allotype and remaining paratypes are in the writer's collection.

*Variation*.—In the series studied there was little variation except in size (males, 6.72–9.14 mm. and females, 6.43–10.3 mm.) and in definition of markings which on most specimens are quite vague, and this variation not being due to abrasion.

*Comparison*.—This species is allied to *obsoletoguttatus* Gory from which it may be easily distinguished by the form of its genitalia, its larger size, different color, more distinct elytral costae, and by the shallow emargination of the prosternal lobe.

### *Agrilus sapindicola* n. sp.

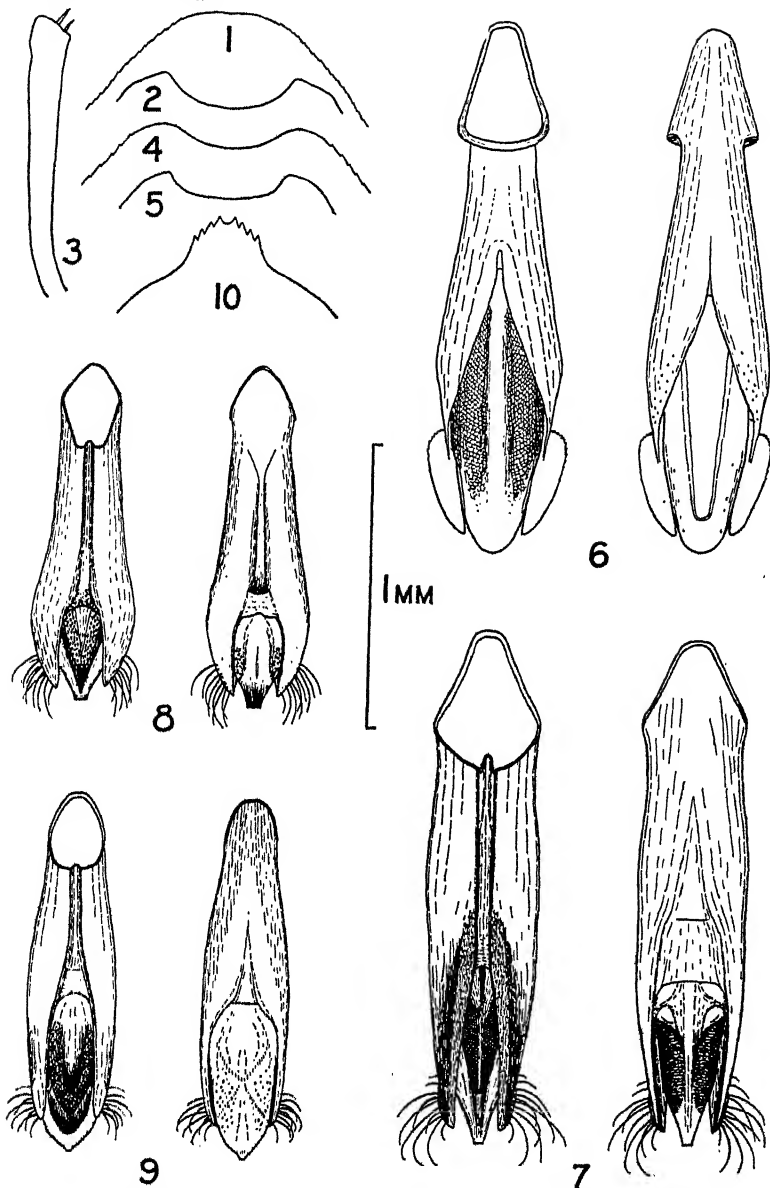
Fig. 8

*Male*.—Form of *obsoletoguttatus* Gory; head rather dull brassy green becoming brassy black on the occiput; pronotum and elytra shining black to bronzy black and ornamented with pubescent markings.

Head with front broad, almost flat, and with median depression feebly indicated; surface finely granulose and sparsely punctate becoming rugose on the occiput and with pubescence coarse and yellowish and limited to the clypeus, the lower portion of the front, and along inner margins of the eyes; antennae almost attaining the posterior angles of the pronotum, serrate from the fourth joint.

Pronotum broader than long, slightly narrower at base than at apex, widest near apex; sides obliquely narrowed from apex to basal third, then somewhat more strongly narrowed to the base, the angle being quadrate; marginal and submarginal carinae sinuate, somewhat broadly separated at middle and connected at basal third; basal margin with median lobe shallowly emarginate; disc convex, with two rather shallow median depressions and broad oblique depressions each side, prehumeral carinae short, divergent and indistinct; surface rugose with sides near margins densely white pubescent-efflorescent. Scutellum transversely carinate.

Elytra wider than pronotum at base, and slightly wider at base than behind middle; sides similar to those in *exsapindi* n. sp; sides of abdomen



In the case of male genitalia, the left hand figure represents the dorsal surface and the right hand figure represents the ventral surface.

*Chrysobothris pubilineata* n. sp. Fig. 1. Last sternite of female. Fig. 2. Clypeus of female. Fig. 3. Fore tibia of male. Fig. 4. Last sternite of male. Fig. 5. Clypeus of male. Fig. 6. Male genitalia.

*Agilus exsapindi* n. sp. Fig. 7. Male genitalia.

*Agilus sapindicola* n. sp. Fig. 8. Male genitalia.

*Agilus obscurilineatus* n. sp. Fig. 9. Male genitalia.

*Pachyschelus fisheri* n. sp. Fig. 10. Sternal process of last sternite of female.



narrowly exposed above and with the anterior half white with pubescence-efflorescence; disc somewhat flattened and with moderately deep basal depressions; surface imbricate punctate, more or less pubescent with short white hairs except for a narrow stripe along the suture and a discoid patch at the apical third almost bare, and each elytron with denser hairs and efflorescence forming a spot in the basal depression, a short vitta extending from the basal fifth to the bare discoid area, and an elongate mark along the apical fourth.

Abdomen beneath brassy black to bronzy black, rather coarsely sparsely punctate, with sparse recumbent pubescence and with the sides of the second and fourth ventrals bearing a small pubescent spot and the sides of the third a rather large patch; first two ventrals without median impression and with the suture obliterated at the sides; pygidium carinate, the carina not projecting; the hind coxae and much of the undersurface of the thorax covered unevenly with white pubescence and efflorescence; prosternal lobe broadly, deeply emarginate. Tibiae slender, first and second pairs toothed at apex. Tarsal claws nearly similar on all feet, simply cleft with inner lobes broad.

Length, 5.17 mm.; width, 1.20 mm.

*Female*.—May be distinguished from male on the following characteristics: first and second pairs of tibiae without tooth at apex; front less granulose; form more robust.

Length, 5.30 mm.; width, 1.33 mm.

*Type locality*.—S. W. Hidalgo County, Texas, one mile south of Granjeno.

*Type material*.—Described from 14 male and 6 female specimens, all collected on succulent foliage of *Sapindus Drummondii* H. and A., March 29–April 5, 1947. Type and three paratypes deposited in the U. S. National Museum (No. 58838); paratypes also deposited in the collections of the American Museum of Natural History and of J. N. Knull; allotype and remaining paratypes are in the writer's collection.

*Variation*.—In the series studied there is little variation except in sizes: males, 3.90–5.17 mm.; females, 4.75–5.54 mm.

*Comparison*.—By Fisher's key<sup>3</sup> this species runs to *obsoleteguttatus* Gory from which it may be distinguished by its size, markings and genitalia.

### *Agrilus obscurilineatus* n. sp.

Fig. 9

*Male*.—Form elongate, subparallel, flattened above; head varying from dull olivaceous to dull bronze and becoming reddish cupreous on the occiput; pronotum and elytra uniformly bright reddish cupreous. Pronotum and elytra with a vague longitudinal white pubescent vitta.

Head with front broad, moderately convex, and wider at top than bottom, median depression slight; surface granulate becoming shallowly rugose on the occiput, sparsely clothed with short recumbent white pubescence. Antennae extending to basal fourth of pronotal margin, serrate from the fifth joint, the outer joints almost as wide as long.

Pronotum wider than long, widest near apex; margins gently nar-

<sup>3</sup>W. S. Fisher, U. S. National Museum Bulletin 145, pp. 1–347, 1928.

rowed to basal third, then more strongly narrowed to just before the base where they broaden slightly; when viewed from the sides, the marginal carina is sinuate, the submarginal carina nearly straight, the carinae widely separated anteriorly and connected to each other near base; disc moderately convex, with distinct median depression, with lateral depressions well marked, and with prehumeral carinae prominent and straight; surface granulose, transversely rugose at the middle, and lateral depressions clothed with short recumbent white pubescence-efflorescence. Scutellum transversely carinate.

Elytra about as wide as pronotum at base and about as wide at base as behind the middle; sides nearly parallel from base to apical third and then attenuate to tips which are separately rounded and serrulate; sides of abdomen narrowly exposed and white with pubescence and efflorescence; disc flattened with broad shallow basal impressions which extend posteriorly the length of the elytra as vague longitudinal impressions; surface finely densely imbricate punctate; pubescence short.

Abdomen beneath bright red cupreous, lightly punctured, and with sparse short pubescence; first two ventrals with a vague to moderately defined median depression; pygidium not carinate. Sides of thorax white with moderately long pubescence and efflorescence; prosternal lobe broad, declivous, and rounded. Posterior coxae with the posterior margin arcuately emarginate. Tibiae straight and slender, anterior pairs with an inconspicuous apical tooth. Tarsal claws similar on all feet, simply cleft.

Length, 5.04 mm.; width, 1.24 mm.

*Female*.—Differs from male in being more robust, and in having the head uniformly reddish cupreous. The basal angles of the pronotum are quadrate and the median ventral impression is absent on the first sternite.

Length, 6.44 mm.; width, 1.76 mm.

*Type locality*.—Starr County, Texas;  $6\frac{1}{2}$  miles southeast of Rio Grande City, beside the highway leading to Mission.

*Type material*.—Described from five male and two female specimens collected on foliage of *Acacia rigidula* Benth. at the above locality on April 12 and 19, 1947. Type and one female paratype deposited in U. S. National Museum (No. 58839); allotype and remaining paratypes are in the writer's collection.

*Variation*.—There are no significant variations except for a tendency for the upper surface to be violaceous in some specimens. Size: males, 5.04–5.59.; females, 6.44 mm.

*Comparison*.—By Fisher's key this species runs to *aeneocephalus* Fisher from which it may be readily distinguished by the genitalia, and by the form of the pronotal margins.

### ***Pachyschelus fisheri* n. sp.**

Fig. 10

*Female*.—Broadly cuneate, broadest at base of pronotum, broadly arcuately narrowed from base of elytra; head and pronotum polished cupreous, with a vague pubescent fascia on each side at the base of the pronotum; scutellum and elytra bright metallic blue with a prominent pubescent fascia at apical third.

Head deflexed, front gibbose and broadly deeply excavate; surface with a few widely scattered punctures and hairs.

Pronotum three times wider than long at middle, much narrower at apex than at base, sides arcuately rounded from base to apex; base broadly deeply emarginate on either side of the scutellum, posterior angles slightly produced; surface impunctate except for the minute punctures bearing the sparsely distributed white setae. Scutellum triangular, smooth.

Elytra at base almost as broad as pronotum, widest at base; sides feebly obliquely narrowed to basal third, then arcuately narrowed to the tips which are conjointly rounded, lateral margins serrulate; disc moderately convex, each elytron with a shallow basal depression and a lateral excavation behind umbone; surface with moderate punctures arranged somewhat in rows and each bearing a fine seta.

Abdomen beneath bronzy black, minutely granulate and bearing a few short hairs; last segment narrowed and broadly produced downward at apex which is rounded and armed with eight rather uniform, stout teeth. Underside of thorax shining bronzy black and bearing a few scattered inconspicuous hairs; anterior margin of prosternum feebly arcuately emarginate; prosternal lobe wanting. Antennal grooves deep, wider at middle and not attaining lateral margins.

Length, 2.99 mm.; width, 1.70 mm.

*Male*.—Differs from female in the last sternite not being produced.

Length, 2.95 mm.; width, 1.70 mm.

*Type locality*.—S. W. Cameron County, Texas. Three miles east of Santa Maria.

*Type material*.—Described from 5 female and 10 male specimens. Twelve of these were collected at the above locality on foliage of myrtle-leaf croton (*Bernardia myricaefolia* (Scheele) S. Wats.) June 8-September 13, 1946-47. The remaining three were reared from leaves of this shrub. Type and two paratypes deposited in the collection of the U. S. National Museum (No. 58840); paratypes also deposited in the collections of the American Museum of Natural History and of J. N. Knull; allotype and remaining paratypes are in the writers collection.

*Variation*.—No significant variations are noted in the series studied, except for size: females, 2.63-3.04 mm; males, 2.80-2.95 mm.

*Comparison*.—This very distinctive species seems closest to the Central American *P. pubicollis* Waterhouse<sup>4</sup> from which it may be readily separated on the basis of its larger size, less cuneate form, gibbose and excavate front, and by the prominence and configuration of the armature of the apical process of the last ventral segment of the female.

The writer takes pleasure in naming this beautiful species in honor of Mr. W. S. Fisher whose many published works have been a constant source of inspiration.

<sup>4</sup>See W. S. Fisher, Proceedings of the U. S. National Museum No. 2454, pp. 1-95, 1922.

# NEW NORTH AMERICAN BEES OF THE GENUS DUFOUREA

(Apoidea—Halictidae)

## PART III

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Four new species and two new subspecies of the genus *Dufourea* have come to light since parts I and II of the series under the above title were written. Addition of these plus the recognition of *D. spilura* (Ckll.) as a valid species raise the total number of recognized species of American *Dufourea* to sixty-one. It is probable that several more will be found within the next few years. This is especially likely in the Sierra Nevada and Coast Range mountains of California where large areas have been inadequately collected for bees from March to May.

Unless otherwise stated, holotypes and allotypes of the new bees herein described will be deposited at the California Academy of Sciences in San Francisco. Paratypes will be distributed to the following collections besides the author's: United States National Museum; University of California Citrus Experiment Station, Riverside, California; American Museum of Natural History, New York. When available, additional paratypes will be sent to other collections upon request.

### *Dufourea subdavidsoni* n. sp.

*Male*.—Length about 9 mm., length of anterior wing 5 mm.; pubescence mostly white to pale testaceous but with hair on scape and the longer hairs on vertex and mesonotum mostly black; integument dark, with distinct bluish metallic reflections to entire body except legs, antennae, abdominal sternum, and apical borders of abdominal tergites. *Head*: Face length over breadth, five over six; eyes nearly parallel, the distance between them at antennal insertion nearly one-fourth greater than eye length; face viewed from in front with distance behind posterior ocellus at least twice as great as ocellar diameter; area between posterior ocellus and nearest point of eye shallowly concave; distance from antennal socket to clypeus about equal to socket diameter; clypeus nearly concealed by reclining whitish pubescence which is mostly longer than antennal scape; upper margin of clypeus and lower parietal region with similarly long but more erect black hair; punctures of frons and vertex coarse and dense, mostly separated by less than one-half a puncture diameter; antennae black to dark brown; scape flattened, about twice as broad as long, bearing long grey and a few long blackish hairs; flagellum as long as hind tibia and metatarsus together, the segments without long hairs and very slightly expanded subapically, fourth flagellar segment with basal two-thirds of upper side smooth; first flagellar segment two-thirds, second three-fourths and third quite

as broad as long; maxilla with stipes about as long as eye; galea beyond palpus about twice as long as broad and sharply pointed; maxillary palpus about half as long as stipes, first segment twice as long as broad, twice as long as second which is subequal to each of remaining segments; labial palpus three-fourths as long as maxillary, first segment three times as long as broad, twice as long as each of remaining, second segment as broad as first, twice as broad as succeeding segments; glossa shorter than labial palpus; mandible only slightly dilated along outer margin, about one-fourth as wide as distance from its apex to eye, its outer basal two-thirds bearing a dense tuft of yellowish hairs as long as the eye. *Thorax*: Mesoscutum, mesoscutellum coarsely, moderately closely punctured, the punctures on the average somewhat less than one puncture width apart except for central area of mesoscutum, the interpunctural areas polished; mesoscutum with short, sparse, whitish hair and long, sparse black hair which is about as long as antennal scape; hypopleural area of mesopleuron with about ten widely scattered punctures; wings definitely yellow-tinged, the first transverse cubital vein offset from the first recurrent by about half its own length; hind wing with seven hamuli; legs very slender, without swollen segments; hind leg with femur three times, tibia four times and metatarsus five times as long as their respective breadths; second and third hind tarsal segments slightly longer than broad and somewhat produced dorso-apically; ventral margin of hind tibia with dense fringe of whitish hairs ranging from about half as long to quite as long as tibia; outer face of metatarsus with scattered, very long hairs; hind tibial spurs long and slender, the inner one four-fifths as long as metatarsus and margined with close-set, needle-like teeth. *Propodeum*: Enclosure coarsely, evenly carinate, with about 12 carinae on either side of mid-line. *Abdomen*: Dorsal portions of tergites with punctures mostly slightly over one puncture width apart and entirely covered with whitish pubescence nearly concealing integument when viewed from in front; posterior tergite borders testaceous, with indistinct hair bands; sternites with distinct apical hair bands in addition to short, erect white hair on remainder of first four; posterolateral hooklets of fourth and fifth sternites represented by a minute swelling and a pit respectively; fourth and fifth sternites each with a discreet area of hair medially on a broadly rounded production of the apical margin which is otherwise broadly emarginate; sixth with a median depressed area bounded laterally by strong carinae and terminated apically by a transverse ridge which is almost at the gently emarginate apex of the segment; posterior arms of seventh broadly rounded apically, somewhat longer than their basal, ventral flaps, and each tipped with a hair tuft as long as the arm; posterior projection of eighth about two and one-half times as long as its basal breadth which is about three times as great as its apical breadth.

*Female*.—Length about 8.5 mm., length of anterior wing 5 mm.; slender in form with pubescence rather long, mostly yellowish white to testaceous but with numerous long sooty to blackish hairs on clypeus, scape, vertex, mesoscutum and posterior margins of apical tergites; integument with distinct bluish tinge on head and thorax but essentially black on clypeus and abdomen. *Head*: Face five-sixths as long as broad; inner eye margins parallel; eye length slightly over three-

fourths interocular width at antennal insertion; distance from antennal socket to clypeus about three-fourths socket diameter; distance from posterior ocellus to vertex about equal to ocellar diameter; hair on clypeus, lower portion of frons as long as apical fringe hairs of clypeus; clypeus with at least 50 punctures; punctures of frons mostly much closer than one puncture width apart except near ocelli; mouthparts (except mandibles) similar to those of holotype. *Thorax*: Mesoscutum with punctures of central half a little finer than those of frons and mostly separated by more than one puncture width; mesoscutellar punctures about one puncture width apart; hypopimeron with lower half bare, upper half densely, coarsely punctured; dorsal vestiture testaceous and short except for numerous long, sooty hairs; hind wing with eight hamuli; posterior tibia over four times, posterior metatarsus over five times as long as their respective breadths; mid tibial spur uniformly testaceous; tibial scopa sparse, whitish ventrally, sooty dorsally. *Abdomen*: First tergite as long as broad and rather uniformly covered with fine punctures which are mostly several puncture widths apart; tergites with subapical hair fringes testaceous to sooty, sparse except on tergites five and six; anal fimbria reddish testaceous.

*Holotype* male, *allotype* female, 8 male and 3 female paratypes: Giant Forest, Tulare Co., Calif., July 16-26, 1923 (C. L. Fox). One male paratype, Tallac, Lake Tahoe, Calif., July 17, (1925?), (E. P. Van Duzee). I also have a female specimen from Gold Lake, Sierra Co., Calif., July 26, 1921 (C. L. Fox) which appears to be this rather than *D. scabricornis* n. sp.

One male specimen from Giant Forest has the first three antennal segments of about the same proportions as the other species of this group. Several of the males also have more black hair on the scape than has the holotype.

This species is very close to *D. davidsoni* (Ckll.), *D. spilura* (Ckll.), and *D. scabricornis* n. sp. The male may be distinguished readily from any of these by the gently emarginate apex of the sixth abdominal sternite. The female has sparser mesoscutal punctures than *D. davidsoni* or *D. spilura* and appears to have finer ones than *D. scabricornis* n. sp. It is probable, however, that some female specimens will prove to be indistinguishable.

#### *Dufourea scabricornis* n. sp.

*Male*.—Very close to holotype of *D. subdavidsoni* n. sp. but differing as follows. *Antennae*: Scape with black hairs more numerous and conspicuous than pale ones; upper side of fourth flagellar segment over one-half and eleventh about one-third roughened; first flagellar segment half, second two-thirds, and third five-sixths as broad as their respective lengths. *Mesoscutum*: punctures rather sparse and irregularly placed, often separated by two or more puncture widths peripherally as well as centrally. *Abdominal sternites*: fourth and fifth with apical hair fringes continuous but reduced sublaterally; sixth with median depressed area produced apically into a pair of projections separated by a V-shaped notch and with the subapical transverse ridge bounded laterally by a pair of bosses.

*Female*.—Very close to allotype of *D. subdavidsoni* but with punctures of mesoscutum considerably coarser than those of mesoscutellum.

*Holotype* male: Brockway, Lake Tahoe, Calif., elev. 6400 ft., July 10, 1941 (G. E. Bohart). *Allotype*: Jenny Lake, Grand Teton National Park, Wyo., July, 1937 (J. W. MacSwain). *Paratypes*: 1 male, Coffee Creek, Trinity Co., Calif., elev. 5500 ft., June 22, 1934 (T. H. Aitken); 1 male, Carrville, Trinity Co., Calif., elev., 2500 ft., June 15, 1934 (G. E. Bohart); 3 males (2 damaged) same as for allotype; 1 male, Timpanogos Mtn. near Provo, Utah, June 25, 1925 (A. L. Melander).

The specimen from Utah is slightly smaller than the others but otherwise the type series is very uniform.

This species is in a closely knit group with *D. davidsoni* (Ckll.), *D. spilura* (Ckll.) and *D. subdavidsoni* n. sp. The male can be distinguished from *D. spilura* by the absence of long hairs on the flagellum, from *D. davidsoni* by the smaller antennae, the greater extent of roughness on the fourth and last flagellar segments, and from *D. subdavidsoni* by the deeply V-shaped notch at the apical margin of the sixth abdominal sternite. It also differs from *D. spilura* and *D. davidsoni* in having relatively unexpanded mandibles, in which regard it resembles *D. subdavidsoni*. The female, represented by one specimen in poor condition, apparently has a more sparsely and coarsely punctured mesoscutum than the related species. There may be justification for considering the four species of this group as subspecies inasmuch as they are practically indistinguishable in the female sex and have fewer distinguishing characteristics in the male than is usual with *Dufourea*. However, no intergradation of essential characters has been found and the territories of at least three of them overlap. To my knowledge, two or more of these species have not been collected together.

#### *Dufourea impunctata* n. sp.

*Male*.—Length about 8 mm., length of anterior wing 4.5 mm.; pubescence wholly pale, mostly white; integument shining jet black, with no trace of bluish or greenish reflections. *Head*: Face length over breadth 5 over 5.5; eyes nearly parallel, very slightly convergent below, the distance between them at antennal sockets slightly greater than eye length; face, when viewed from front, with distance behind posterior ocellus nearly twice ocellar diameter; area laterad to posterior ocellus flattened; distance from antennal socket to clypeus slightly greater than socket diameter; clypeus, supraclypeal area largely concealed by dense, white pubescence, long and suberect on the former, prostrate on the latter except laterally; punctures of frons coarse, mostly separated by about one puncture width except for nearly impunctate areas surrounding ocelli; pubescence of frons, cheeks long, sparse, entirely pale; antennae black basally, dark brown above on last ten segments, about one-half as long as anterior wing, the flagellar segments not at all swollen medially, slightly broader than long except for last two which are longer than broad; underside of flagellum distinctly flattened, with several rows of pale hairs bent at their middles to right angles and about half as long as flagellar width; scape nearly as broad as long, covered with long white hair; maxillary stipes three-fourths as long as hind tibia; the galea beyond palpus about one-third as long as prepalpal portion and less than three times as long as broad; maxillary palpus five-sixths as long as stipes, the second segment about three times as

long as broad and one-third longer than any of others which are subequal; labial palpus about three-fourths as long as maxillary, the first segment equal to next two combined. *Thorax*: Mesoscutum polished, nearly impunctate except for fine scattered punctures anterior and lateral to parapsidal furrows; mesoscutellum more densely punctured but with punctures rather fine and mostly two or more puncture widths apart; mesoscutal and scutellar hair long, white, sparse, not at all concealing integument from any view; wings clear, without yellow or grey tinge, the veins pale testaceous; first recurrent vein offset from first transverse cubital by nearly its own length; hind wing with seven hamuli; legs somewhat swollen but without striking modifications; femora about half as broad as long, the first two broadest subbasally; hind tibia about two and three-fourths times as long as broad; hind metatarsus parallel-sided, about three and one-half times as long as broad; next three segments about as broad as long, slightly produced posteriorly; hind tibial spurs not over half as long as metatarsus, their margins with numerous, fine, close-set teeth. *Propodeum*: Enclosure strongly, evenly carinate throughout, with about 18 distinct carinae on either side of mid line; vertical posterior portion of enclosure smooth, without transverse carinae even at summit. *Abdomen*: Tergites with very sparse, setigerous punctures, the central two-thirds of the first almost impunctate; posterior tergite borders transparent, appearing black when closely applied to succeeding segments, and not preceded by distinct hair bands except for sparse ones on fifth and sixth tergites; sternites polished, with indistinct, fine pubescence except for that of apical borders where it forms a band of erect to recurved hairs on third and fourth segments; fourth also with a pair of strongly recurved hooklets posterolaterally; fifth evenly emarginate; sixth medially depressed, with a flat, subtriangular, apically truncate projection, about as broad as long, a little longer than antennal scape, and entirely covered with a long, dense tuft of yellowish hair; posterior arms of seventh with long hair tufts and about half as broad as their lengths beyond the basal flaps which have inner, apical, pointed extensions; apical projection of eighth with proximal half triangular, distal half nearly parallel-sided, less than one-fourth as broad as base.

*Holotype* male, 1 male *paratype*, "So. Cal." from the collection of the Philadelphia Academy of Sciences where the holotype will be deposited.

This is a very distinct species, probably related to *D. nudicornis* Timb. but easily separated by its non-crenulate antennal flagellum which bears bent hairs ventrally. Its non-metallic integument and sparse punctation distinguish it from species having similar antennae.

#### *Dufourea convergens* n. sp.

*Male*.—Length about 6 mm.; length of anterior wing 4.5 mm.; hair wholly pale, mostly white, rather long, not dense; integument dark greenish blue; body rather robust. *Head*: Face length over breadth 6 over 7.5; eyes distinctly convergent below, the distance between them at their lower margin three-fifths that at their extreme summits; eye length slightly less than distance between them at antennal insertions; clypeus over twice as broad as long, densely punctured, covered with



long, dense, reclining, white hair; supraclypeal area similarly punctured and haired; distance from antennal socket to clypeus about equal to socket diameter; hair of cheeks, frons, vertex white, long, quite sparse; frons, vertex moderately finely, closely punctured, the punctures mostly less than one puncture width apart, but somewhat sparser near ocelli; area between lateral ocellus and compound eye well rounded; face, viewed directly from in front, with distance behind lateral ocellus less than half ocellar diameter; antenna short, black to dark brown, flagellar segments, except first, as broad as or broader than long, the apical seven each slightly crenulate on outer side; scape rather flat, over twice as long as broad; flagellum bare except for usual minute general pubescence; maxilla with stipes about four-fifths as long as hind tibia; galea about one-third as long as stipes, narrowly rounded apically; maxillary palpus about two-thirds as long as stipes, first segment about three times as long as broad, a little longer than second, twice as long as any of remaining segments; labial palpus about half as long as stipes, first segment as long as next two combined. *Thorax*: Mesoscutum finely, rather densely punctured, the punctures somewhat less than one puncture width apart anteriorly and laterally, slightly more centrally, posteriorly; mesoscutum with short, white pubescence in addition to longer, sparser white hair (rather matted with moisture in available specimen); area above mesonotal spiracle bare ventrally, with about 15 fine punctures dorsally; thorax remarkably broad and deep for the genus; wings slightly brownish, the first transverse cubital vein offset from first recurrent by two-thirds its own length; legs of moderate girth and not conspicuously modified; fore and mid femora over twice as long, hind femur thrice as long as broad; hind tibia four times as long as broad, nearly as broad apically as subapically, covered with white hair which is much shorter than tibial width; hind metatarsus five times as long as broad, the succeeding two segments each nearly twice as long as broad. *Propodeum*: Enclosure five times as broad as long, the median half with fine, irregular carinae, the lateral portions with rather widely spaced, regular carinae. *Abdomen*: First tergite highly polished, with rather numerous but very fine and widely separated punctures; succeeding tergites with subapical hair bands weakly developed, those of fourth and fifth scarcely distinct from general pubescence; apical tergite with a distinct narrow, bare pygidial area; sternites nearly bare, without sublateral hooklets or callosities; fourth and fifth sternites simply transverse on apical margins; sixth unmodified except for a very small, pointed but flat apical projection; apical lobes of seventh broadly rounded distally, the portions projecting beyond their basal, ventral flaps about as broad as long; apical projection of eighth slender nearly to extreme base, with the distal swelling, viewed from the side, shaped like a short foot with a well-developed instep; penis valves, viewed from the side, with free portions leaf-like, each about two-thirds as broad as long, highly arched dorsally, and extending for one-third its length beyond the gonostyli.

*Holotype* male (unique): San Diego, California (collector and date of collection unknown); from California Academy of Sciences collection.

This is in a small, compact group including *D. leachi* Timb. and *D. viridis* Timb. The group is easily distinguished in the male sex by

the relatively simple sixth sternite and by the globose genitalia. Females resemble members of the *D. sandhouseae* (Mich.) group quite closely. *D. convergens* may be separated from *D. viridis* by its blue instead of green color and by the foot-like structure at the apex of the eighth sternite. It may be separated from *D. leachi* by the eyes which are more strongly convergent below and by the penis valves which are more highly arched and extend considerably beyond the gonostyli.

***Dufourea australis mexicana* n. subsp.**

*Male*.—Differs from *D. australis australis* (Mich.) and *D. australis dammersi* Timb. (new combination) in being smaller (body length 6 mm. and anterior wing length 4 mm. as against average measurements of 8 mm. body and 5 mm. wing for the other subspecies), and narrower (distance between tegulae 1 mm. as against an average of nearly 1.5 for the others). It also has a more nearly jet black ground color with the posterior tergite borders showing black instead of brown against the succeeding tergites. The vestiture is very sparse and that of the scape and paracocular areas has many sooty hairs in addition to white ones. Punctuation is moderately sparse and fine, the punctures of mesoscutum and mesoscutellum being mostly separated by two or more puncture widths and those of the first apparent tergite by three or four.

*Female*.—Differs from the other subspecies in essentially the same characteristics as the male. Its body and wing length compare closely with the male's and its ground color, vestiture length and color, and punctuation likewise differ from the other subspecies. It has closer punctuation than the male, the punctures of the anterior half of the mesoscutum being slightly less than one and of the central portion about one puncture width apart. Punctuation of females of the other subspecies is still closer. An additional difference exhibited by the female is the considerable amount of sooty mesoscutal pubescence.

*Holotype* male, *allotype* female, 8 paratype females and two paratype males, La Laguna, Sierra Laguna, Lower California, October 14, 1941, from a composite (G. E. Bohart and E. S. Ross).

This may represent a distinct species but its distinguishing characteristics of size, ground color, hair color, and density of punctuation are usually considered of subspecific value. It seems to represent the small, dark, sparsely punctured extreme of a series of subspecies in which the other extreme is the relatively large, yellowish haired, densely punctured *D. australis australis*.

***Dufourea sandhouseae arida* n. subsp.**

*Male*.—Differs from *D. sandhouseae sandhouseae* (Mich.) in having the hind tibia slightly less than one-third as broad as long (in the latter it is usually one-third or more) and in having a brighter yellow antennal flagellum. Punctures of the central portion of the mesoscutum are quite fine and average at least two puncture widths apart. In most males of *D. sandhouseae* s. str. the thoracic punctures are somewhat closer. The clypeus has a patch of long, erect hairs confined to the central portion whereas in most *D. sandhouseae* s. str. it occupies most of the clypeus.

*Female*.—Outer side of antennal flagellum reddish testaceous on

apical six segments instead of dark brown to dull yellowish brown as is the case with most *D. sandhouseae* s. str. As in the male, punctuation is slightly finer.

*Holotype* male, *allotype* female, four male and two female paratypes: Westgard Pass Plateau, Inyo Co., Calif., May 27, 1937, from *Phacelia* (C. D. Michener). Other paratypes: one male, Westgard Pass, Calif., May 19, 1947 (R. M. Bohart); 1 male and females, Mt. Springs Cyn., Argus Mts., Inyo Co., Calif., elev. 5000 ft., May 22, 1937 (N. W. Frazier); 4 males, Palmdale, Los Angeles Co., Calif., April 11, 1936 (G. E., R. M. Bohart); 1 male, Baker, Calif., March 15, 1935; 1 male, Poway, Calif., March 22, 1890 (F. E. Blaisdell).

This subspecies represents an arid type. Intermediate specimens are found in the inner Coast Ranges (Priest Valley, Monterey Co., Calif.) and occasionally in any area largely populated by distinctive members of one or the other subspecies. Antennal flagellar color of the males from Inyo County varies from reddish yellow to a rather pale yellow but does not assume the dull brownish yellow typical of the more coastal form. Females of *D. s. arida* are apt to be confused with females of *D. malacothricis* Timb. in whose territory they are frequently found. The latter differ principally in having very fine and rather sparse mesonotal punctures.

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THE LARVAE OF INSECTS, PART I, LEPIDOPTERA AND HYMENOPTERA, by ALVAH PETERSON. 315 pp., 84 plates. Lithoprinted, Edwards Brothers, Inc. 1948. Price, \$5.00.

As important as the identification of immature insects is, this field of study has been badly neglected, and even the appearance of some important recent work has not atoned for the deficiency. So far, we have had no comprehensive manual for the identification of immature forms. The appearance of Dr. Peterson's work, therefore, is very welcome.

The present volume, the first of two parts, presents an introduction to the subject, with a discussion of collecting, killing, dissecting, and preserving methods and a description of the techniques of inflating and restoring larvae. Keys are given to the immature stages, excluding eggs, of all important orders, and a selected list of references is presented. Two orders, the Lepidoptera and the phytophagous Hymenoptera, are considered in detail, with keys, family characterizations, and lists of citations. A glossary and host indices, in addition to the general index, will increase the usefulness of the work.

The plates of illustrations have reproduced well. The scheme of numbering is interesting: plates O1 through O14 illustrate the orders in general, plates L1 through L58 the Lepidoptera, and plates H1 through H12 the Hymenoptera. The descriptive material accompanying each plate attempts to point out the distinctive morphological characteristics of the form illustrated and, in cases involving a definite species, other useful information is given.

The work has been tested through use, in preliminary form, by Dr. Peterson's students in his course in larval taxonomy. It impresses one as a well prepared manual, and minor criticisms that one might have of it seem trivial. We are anxiously anticipating the appearance of Part II, which, according to the statement in the introduction, is to deal with the Coleoptera, Diptera, Siphonaptera, Neuroptera, Trichoptera, and Mecoptera.—M. T. J.

# A LABORATORY METHOD FOR REARING COCK-ROACHES, AND ITS APPLICATION TO DIETARY STUDIES ON THE GERMAN ROACH<sup>1, 2</sup>

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Cockroaches are popular insects for experimental studies, for they are readily available, of a convenient size, and grow at all seasons of the year. Their method of reproduction is such that a large number of nymphs hatch at once, making them ideal experimental animals for comparative quantitative studies. It is surprising, therefore, that no standard methods of rearing these insects have come into general use. A review of the more common methods of laboratory culture was presented by Campbell and Moulton (1943).

Various materials have been used as maintenance diets for stock colonies of cockroaches. For the German roach, *Blattella germanica* (L.), McCay and Melampy (1937) employed a mixture of ground whole wheat, dried skim milk powder and dry baker's yeast. Gould and Deay (1940) used "Pablum baby food, pulverized dog biscuit or Haydak's laboratory food." For the American roach, *Periplaneta americana* (L.), Griffiths and Tauber (1942) used "a diet of whole wheat bread, banana, and raw beef," while Gier (1947) used miscellaneous foods including "raw potatoes supplemented monthly with a little raw lean meat or unsorted table scraps." No quantitative studies on the relative effectiveness of these stock diets have been reported.

Environmental factors have been studied in more detail. Biometric data on the German cockroach were reported by Woodruff (1938, 1939), while similar studies were made on the American species by Gier (1947). The effect of temperature on the rate of development of five species of cockroaches was reported by Gould and Deay (1940), and by Gould (1941), who found that raising the temperature from 25° to 30° C. shortened the hatching period of the German roach from 28 to 17 days, and the nymphal period from 103 to 74 days. A temperature higher than 30° was unsatisfactory because of increased mortality.

Under ordinary conditions fluctuations in relative humidity seem to have no harmful effects. Thus, Gier (1947) noted no seasonal differences in hatchability of *P. americana* egg-sacs maintained in an incubator at 30° C. over a period of three years at a "reasonable humidity;" Gould and Deay (1940) recorded changes in relative humidity ranging from a low of 10 per cent in the winter to very high values in summer with no reported ill effects. However, a "humidity preference" was

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demonstrated by Gunn (1931, 1934) and Gunn and Cosway (1938) for the Oriental cockroach, which was influenced by the temperature, and hence, the drying capacity of the air.

Necheles (1927) observed that changes in light did not affect the activity of *P. americana* or *Blatta orientalis* (L.) directly, although it is common knowledge that cockroaches prefer to come out after dark to feed, remaining in hiding during the day. There is no startle reaction when roaches are suddenly exposed to light, as may readily be observed.

Nymphs of *B. germanica* reared in isolation were found by Pettit (1940) to require a longer period of time to reach maturity than nymphs reared in groups. A crowding effect was observed in *B. orientalis* by Landowski (1938) who reported an increased mortality, a shortened nymphal period, and a smaller adult size as a result of increasing the density of population in small containers. Similarly Griffiths and Tauber (1942) recorded a poorer reproductive performance of mating pairs of *P. americana* reared in small containers as compared to those in larger containers.

Sexual and genetic influences on the growth rate have received some attention. Gier (1947) reported that female nymphs of *P. americana* became significantly heavier than the males only after the last nymphal moult, and that the number of moults was the same for both sexes. Griffiths and Tauber (1942) have suggested that local "strains" of the American roach may have quite different growth rates, thus accounting for some of the wide variations in growth rate reported in the literature for this species.

A considerable degree of individual variation in growth rate has been reported. Gould and Deay (1940) recorded a variation in nymphal development of *B. germanica* from 37 to 127 days, with an average of 74 days, when reared at a constant temperature of 30° C. Similarly, Gier (1947) reported variations in the time of the imaginal moult within a group of nymphs of *P. americana* reared for growth studies from 200 to 430 days.

The method described below has been developed for the study of the nutritional requirements of the cockroach *B. germanica*. Since this method has yielded quantitative and reproducible results over a period of more than a year in testing some 300 synthetic diets, and since other physiological studies may be made by the same procedures, the techniques are described in detail.

#### EQUIPMENT AND PROCEDURES

*Apparatus.*—The standard rearing unit illustrated in fig. 1 consisted of a group of test tube cages arranged on a rack, with the horizontal tubes spaced by a strip of tin folded into loops, and the vertical tubes spaced by means of furniture nails. The individual rearing cage consisted essentially of three test tubes of different sizes. The large horizontal chamber was made from a 25 x 200 mm. test tube with the rounded end cut off and replaced by a fine (50 meshes per inch) wire cloth. The latter was sealed to the cut end with an adhesive consisting of a 1 : 1 mixture of beeswax and rosin. The feeder was a 10 x 50 mm. test tube placed with the open end toward the screen after being half-filled with the diet. The water reservoir was an 18 x 150 mm. test tube

resting against the rack in an inverted position. The watering tube was made from a piece of 8 mm. glass tubing 12 cm. long, bent in the middle at an angle of 120 degrees. To prevent this tube from leaking the lower end was heated until the opening had constricted to a diameter of 3 mm. The hole receiving this tube was bored in the large (No. 4) rubber stopper at an angle of 30 degrees to its midline, and the stopper beveled at the lower surface to allow the watering tube to project slightly from the stopper. A small (No. 1) rubber stopper served to connect the watering tube with the reservoir.

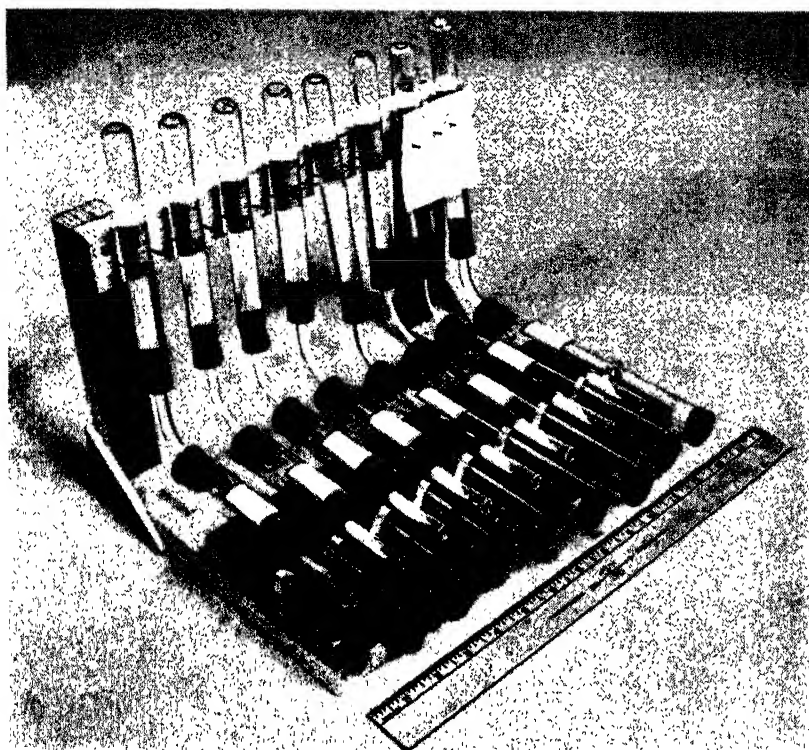


FIG. 1. The standard rearing unit for *Blattella germanica*.

Three modifications of this basic design have been used. One intended for dietary experiments on mineral requirements in which the metallic screen, a possible source of contamination, was replaced by a "chimney" plugged with cotton, is shown in fig. 2, center. A further modification (not illustrated) has been used in attempts to rear *B. germanica* under sterile conditions. In this design both rubber stoppers were eliminated by sealing the watering unit directly to the horizontal cage. The open end of the cage was plugged with cotton, and the upper end of the water reservoir was closed with a hypodermic stopper through which sterile water was injected with a syringe. The entire assembly,

including the diet, was autoclaved before the introduction of a sterilized ootheca.

An oversize modification of the cotton-plugged cage described above has been used in preliminary experiments with *P. americana* and *B. orientalis*. It is shown in fig. 2, left. The horizontal cage consists of a 38 x 200 mm. test tube for both species. The feeder for the American roach should be 20 mm. in diameter, while a 16 mm. feeder is adequate for the Oriental roach.

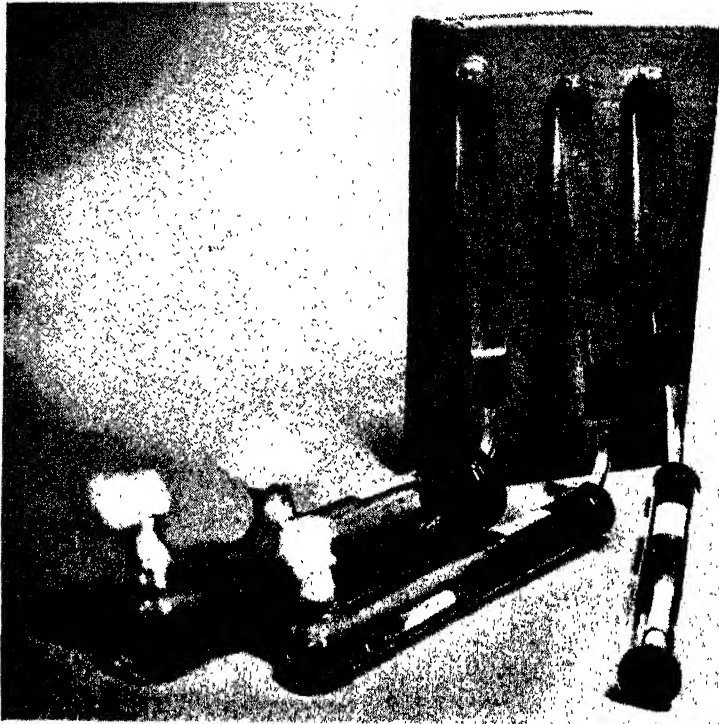


FIG. 2. Three types of rearing cages for cockroaches. Right to left: standard rearing cage for *B. germanica*; cotton-plugged cage for use in studies on mineral requirements; oversize modification used for *P. americana* and *B. orientalis*.

*Rearing room.*—The cages were kept on shelves in the anteroom of a 39° C. incubator. The temperature was subject to daily fluctuations from 26°C. to 33°C., with an average of about 30°C. The humidity was uncontrolled.

*Stock colony.*—The stock colony of *B. germanica* was maintained in the screened cages described above, with one mating pair per cage. At weekly intervals the diet, consisting of pulverized dog biscuits and water, was renewed. Data on the number of egg-sacs produced and the number hatching from each egg-sac were obtained by daily observations. A systematic breeding program has been followed for the purpose of standardizing the strain.

## NUTRITION EXPERIMENTS

For a typical dietary experiment a hatching of day-old nymphs was distributed among the eight cages of a rack, allowing about 5 nymphs to a cage. The control group was fed pulverized dog biscuits, and the remaining seven groups were fed synthetic diets. The growth response ordinarily was compared only among the groups of one rack. Also, over a period of time, the growth response to the control diet could be compared for a series of successive experiments, as described below. At weekly intervals each of the feeders was replaced and the water renewed. The experimental diets were kept in a refrigerator at all times. The rate of growth was measured by weighing each group to within 0.5 mg. at ages of 10, 20 and 30 days. Weighings were made after anaesthesia with carbon dioxide. Nitrogen, ether and chloroform have been found by experiment to be much inferior to carbon dioxide as anaesthetics for *B. germanica*. A daily record was kept of the age and sex of maturing individuals. Selected groups were saved for obtaining data on reproduction.

*Experimental diets.*—Two crude diets and two synthetic diets which have been fed often enough as control diets to yield data on the reproducibility of growth response of *B. germanica* (Table I) have the following compositions:

CRUDE I	Per cent
<sup>3</sup> Pulverized dog biscuits.....	100

CRUDE II	Parts
<sup>3</sup> pulverized dog biscuits.....	95
corn oil.....	5
cholesterol.....	0.1

SYNTHETIC I	Per cent
glucose monohydrate.....	74
casein (alcohol extracted).....	15
corn oil.....	5
<sup>4</sup> Wesson's salt mixture.....	4
cholesterol.....	1
L-cystine.....	0.6
<sup>5</sup> vitamin mixture.....	0.4

SYNTHETIC II	Per cent
glucose monohydrate.....	61.6
casein (alcohol extracted).....	30
corn oil.....	3
<sup>4</sup> Wesson's salt mixture.....	4
cholesterol.....	1
<sup>5</sup> vitamin mixture.....	0.4

<sup>3</sup>Friskies brand. Manufactured by Albers Milling Company, Peoria, Illinois.

<sup>4</sup>Wesson, L. G., Science 75, 339 (1932).

<sup>5</sup> Vitamin	micrograms/gram		micrograms/gram
thiamine HCl.....	12	Choline Cl.....	1000
riboflavin.....	18	inositol.....	2000
pyridoxine HCl.....	16	vitamin K	
nicotinic acid.....	100	(menadione).....	1
calcium pantothenate.....	40	biotin.....	0.6
para-aminobenzoic acid.....	50	folic acid.....	5



TABLE I  
REPRODUCIBILITY OF GROWTH RESPONSES OF *B. germanica* NYMPHS  
REARED ON FOUR DIFFERENT DIETS  
(Data assembled from 25 separate experiments.)

DIET	DATE	STRAIN	WEIGHT IN MILLIGRAMS		MATURITY, DAYS		TEMPER- ATURE, DEGREES C.	SEX	
			20 days	30 days	Average	Range		Average	M.
Crude I .....	1-2	B	18	32	44	42-49	29.0	2	2
	1-10	A	19	44	40	38-42	29.2	2	2
	1-15	B	21	43	39	34-42	29.2	4	1
	1-18	B	20	48	39	33-45	29.6	4	3
	2-6	B	20	36	41	40-42	29.7	4	1
	11-23	B	25	50	38	35-41	29.6	2	3
	Average		20	42±4.6	40±2.0		29.4		
	Standard deviation of males		= 40.2 ± 3.1						
	Standard deviation of females		= 39.6 ± 2.0						
	Crude II	10-23	I <sub>4</sub>	..	34	42	41-42	28.7	2
10-30		B	..	55	35	32-37	28.7	2	4
11-4		B	..	64	34	31-36	29.0	1	5
11-8		W	..	39	39	33-42	29.0	6	1
11-14		W	20	46	39	35-45	29.3	3	2
11-23		B	19	44	38	35-41	29.6	2	3
11-29		W	11	..	43	41-45	29.7	3	2
12-8		B	17	31	42	41-43	29.0	2	1
Average		17	45±10.8	39±3.1		29.1			
Standard deviation of males		= 39.8 ± 3.5							
Standard deviation of females		= 37.2 ± 3.0							
Synthetic I	2-11	W	11	18	57	54-63	29.0	3	2
	5-4	W	..	22	57	52-64	28.9	3	2
	5-4	W	..	24	53	47-58	28.9	2	3
	5-4	W	..	20	61	48-84	29.3	4	1
	10-30	B	..	39	47	39-50	29.0	0	4
	Average		..	25±7.5	55±4.7		29.0		
Standard deviation of males		= 57.5 ± 9.1							
Standard deviation of females		= 53.4 ± 6.2							
Synthetic II	1-2	B	17	32	44	40-50	29.0	3	2
	1-15	B	11	23	51	49-57	29.2	3	2
	1-18	B	14	26	48	44-50	29.6	0	4
	2-6	B	11	21	50	49-53	30.0	2	2
	11-29	W	10	17	54	45-60	29.2	3	4
	12-8	B	14	31	48	44-50	29.1	2	4
	Average		13	25±5.3	49±3.1		29.3		
	Standard deviation of males		= 49.0 ± 4.2						
Standard deviation of females		= 50.0 ± 5.2							

## RESULTS

The growth responses of *B. germanica* nymphs to the four diets listed above are presented in Table I. Each of these diets was used as a control for separate experiments set up at different times. Results from 25 experiments are listed.

Roaches fed the crude diets matured in an average of 40 days, in contrast to 74 days recorded by Gould (1941) for this species reared under similar conditions. However, maturation was delayed on the two synthetic diets. The average age at maturity was 55 days on synthetic diet I (range 47-61 days for separate groups), and 49 days (range 44-54) on synthetic diet II. The average weights at 30 days were 42 and 45 mg., respectively, on the two crude diets, as compared with 25 mg. on the two synthetic diets.

The month and day at which each experiment was started is listed in the second column of Table I. No consistent variations in growth rate could be attributed to seasonal effects.

Column three of Table I lists four strains of *B. germanica* which were used in dietary experiments. Strain W represents nymphs which hatched from eggs of wild adults captured in the laboratory of the Biochemistry Building at the University of Wisconsin. Strain A adults were captured in the basement of a grocery store in Madison, Wisconsin, and strain B adults were captured in a bar located in another part of the city. Strain I<sub>4</sub> is the fourth inbred generation from the W strain. There were no consistent differences in growth rate noted which could be correlated with the different strains. However, the young of inbred group I<sub>4</sub> matured within a period of 2 days, in contrast with much greater ranges in time of maturity for the other three groups. A tendency toward greater uniformity in inbred strains has also been recorded in several other experiments not reported here.

The weights of the nymphs at 20 days listed in column four of Table I have not been used as the main criteria of growth response, since these weights do not always parallel the weights at 30 days or the age at maturity. However, a weight at 20 days is sometimes useful in dietary experiments in which an indication of the shape of the growth curve is desired. Furthermore the growth at this time is often helpful in planning the next experiment.

Two criteria of growth, weight at 30 days and age at maturity, columns five and six of Table I, were analyzed for variability and the standard deviation was calculated for each of the four diets. The standard deviation in age at maturity was  $\pm 2.0$  days and  $\pm 3.1$  days, respectively, for the crude diets, and  $\pm 4.7$  days and  $\pm 3.1$  days, respectively, for the synthetic diets. The corresponding standard deviations in weights at 30 days were  $\pm 4.6$  mg.,  $\pm 10.8$  mg.,  $\pm 7.5$  mg., and  $\pm 5.3$  mg., respectively. Hence the weight data were appreciably more variable than the data on maturation. Sex probably is an important contributing factor to the high variability in weight at 30 days, since the adult females weigh roughly one-third more than adult males. The two sexes, however, mature at approximately the same rate, as indicated by statistical analysis of the data on 64 males and 64 females in the 25 groups presented. This similarity between sexes was noted on each of the four diets tested. The standard deviation in the age of maturity for each sex tended to be greater than the overall standard

deviation for the group. This indicates that sex has little or no effect on the speed of maturation. Hence data on age at maturity are very useful in estimating the overall biological performance of *B. germanica*, as modified by diet.

#### SUMMARY

1. An apparatus and method are described for rearing groups of the cockroach *Blattella germanica* (L.) in comparative quantitative studies. An oversize modification of the apparatus has been found suitable for two other species of roaches.

2. Groups of *B. germanica* nymphs fed two crude diets matured at an average of 40 days  $\pm$  2.0 days, and 39 days  $\pm$  3.1 days, respectively. Nymphs fed two synthetic diets matured at an average of 55 days  $\pm$  4.7 days, and 49 days  $\pm$  3.1 days, respectively.

3. Seasonal and genetic variations in growth rate were not significant. However, growth appeared to be more uniform in inbred strains, as compared with first generation insects from natural populations.

4. The average weight of nymphs at 30 days showed roughly twice the variability of the average age at maturity, probably because of sexual differences in weight.

5. The average age at maturity is a useful index of biological performance of *B. germanica*, and it is not significantly affected by sex.

#### ACKNOWLEDGMENT

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# A STUDY OF THE GENUS GESOMYRMEX MAYR, AND A DESCRIPTION OF A SPECIES NEW TO THE GENUS

(Hymenoptera: Formicidae)<sup>1</sup>

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The genus *Gesomyrmex* is of particular interest to the myrmecologist because only four living species and one variety have been known and these very rare insects probably represent "vanishing relicts of a group of Formicidae with huge eyes and 8-jointed antennae which was represented by numerous species during the Oligocene and Miocene Tertiary." (Wheeler, 1921, p. 114)

The genus *Gesomyrmex* was established by Mayr (1868, p. 50) for a single species, *hoernesii*, obtained from Baltic amber. Emery (1891, p. 581) described as new *G. corniger* from worker specimens in Sicilian amber. However Wheeler (1914, p. 111) showed that Emery's specimens, which are armed with long spines on head and thorax, are generically distinct from *Gesomyrmex*, and he erected for them the genus *Sicelomyrmex*. André (1892, p. 47) described a living species of *Gesomyrmex*, which he named *chaperi*, collected from the Kapoewas Basin, North Borneo. André (1892, p. 49) described a larger form with a more rectangular head and smaller eyes from the Kapoewas Basin and erected for it a new genus, *Dimorphomyrmex*, naming the genotype *D. janeti*. Emery (1905, p. 188) described from Baltic amber a form closely related to *D. janeti*, which he named *D. theryi*. Wheeler (1914, p. 107) described *G. annectens* and *D. mayri* from Baltic amber. The same author (1916, p. 16) described a single alate female from Luzon, P. I. and named it *D. luzonensis*.

From two workers collected near Canton, China, Wheeler (1929, p. 112) described *G. howardi*. Wheeler (1929, p. 2) described *G. kalshoveni* from 15 workers (4 maximae, 8 mediae, and 3 minimae) which had been collected in a teak forest at Semarang, Java. In this paper Wheeler states (p. 2) that "the new species from Java now shows that the specimens of *howardi* are really media and minima workers, that those of *G. hoernesii* and *chaperi*, described by Mayr and André are minimae, that those of *D. janeti* are maximae and mediae of *G. chaperi*, and that the workers of *D. theryi*, *D. mayri* and *G. annectens* are in all probability the maximae, large mediae and small mediae respectively of *G. hoernesii*." Wheeler (1930, p. 35) described *G. luzonensis* var. *chapmani* from a series of 43 workers<sup>2</sup>, a single female, and a single male from Dumaguete, Negros Oriental, P. I. In this paper Wheeler had to compare the workers of the new variety with those of *G. kalshoveni*, inasmuch as the typical *luzonensis* is known only from the female.

I have been unable to find in the literature subsequent to 1930

<sup>1</sup>Contribution No. 18, Department of Zoology and Entomology, University of Tennessee.

<sup>2</sup>The number in each caste is not specified.

further references to either collections or descriptions of forms of *Gesomyrmex*. In my collections of Indian ants I have found a series of *Gesomyrmex* workers which are apparently representative of a new species. A description and figure follow.

***Gesomyrmex spatulatus* n. sp.**

*Holotype*, major worker (Pinned specimen, Cole collection No. A-136).—Overall length of body, 5.09 mm.; length of head, excluding mandibles, 1.27 mm.; length of thorax, 1.97 mm.; length of gaster, 1.85 mm.

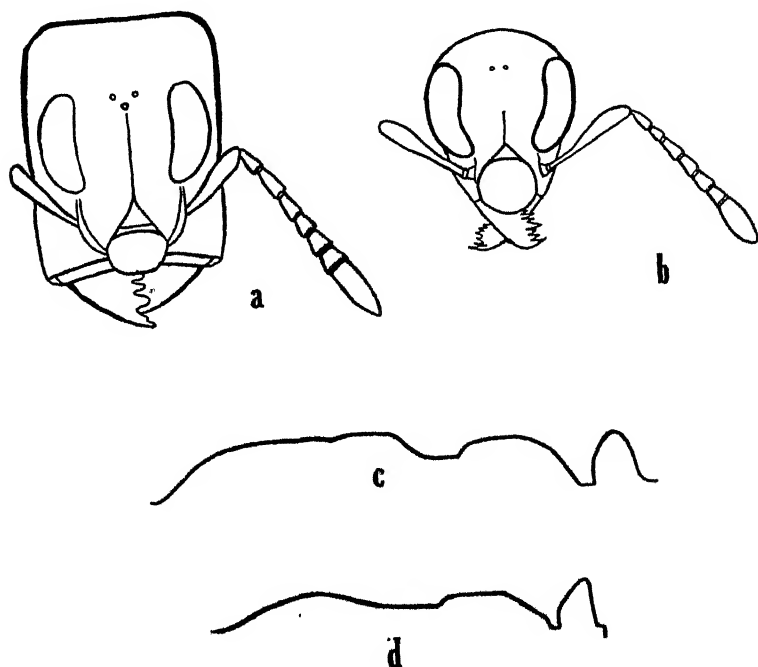


FIG. 1. *Gesomyrmex spatulatus* n. sp. a, head of major worker; b, head of minor worker; c, thoracic profile of major worker; d, thoracic profile of minor worker.

Head, excluding the mandibles, distinctly longer than broad, rectangular, only very slightly broader behind than in front; the sides subparallel, slightly concave in front of the middle; posterior corners sharply rounded; posterior border nearly straight; occipital margin broadly and arcuately excized; gular surface rather flat. Eyes large, elliptical, approximately twice as long as broad, slightly narrower anteriorly than posteriorly, located dorsad to the middle of the genae, the distance from the upper eye margin to the upper border of the head more than twice that from the lower eye margin to the antennal insertion. Lateral ocelli minute but distinct, unpigmented; median ocellus even smaller, indistinct. Mandibles rather flat, broad, the inner

border concave, the outer border convex; apical tooth short, broad, blunt; other teeth short, broad, rather blunt, and crowded. Clypeus subhexagonal, broader than long, flattened, ecarinate, rather triangularly depressed just below the middle; anterior margin broad, subtruncate, slightly but not distinctly covering the inner margins of the mandibles when they are in repose. Frontal area large, triangular, distinct, its angles nearly equal. Frontal groove distinct, rather deep in its central portion, extending from upper corner of frontal area to just below the lateral ocelli. Frontal carinae distinct, extending from the lateral clypeal margins to the lower borders of the compound eyes, broader in the middle, deflected laterally and obscuring the antennal insertions. Antennae short, eight-jointed; scape rather sharply incrassated from the middle apically, its distal end extending to a little more than half the length of the compound eyes, its apex a little more than twice the width of its base; funiculi with the first three segments longer and more slender than the remaining segments (except the terminal segment) which become increasingly broader apically; terminal segment longest of all and slightly broader than the penultimate segment, rather pointed, forming the end of a rather indistinct club.

Thorax long and slender, broadest through the pronotum, much narrowed at the mesonotum; pronotum seen from above elliptical, the length and breadth subequal; pronotum seen from the side evenly and broadly convex, except for the anterior declivity which is rather steep and slightly concave near its base; promesonotal impression shallow; constriction between mesonotum and epinotum broad, flattened, bearing on each side a tubercle supporting a spiracle; upper surface of epinotum extending above the mesoepinotal impression, slightly convex, a little longer than the rather steeply sloping, flat, posterior declivity, bearing on each side a large, posteriorly directed spiracle; mesonotum as broad as long, about half as broad as the pronotum; epinotum longer than broad, a little narrower than the pronotum. Petiolar node a little higher than the epinotum, its anterior surface convex, its posterior surface more flattened and declining posteriorly from apex to base where it joins the keel-like margin of the petiole; its superior border broadly but very distinctly emarginate, the excision continuing as a shallow groove along the middle of the anterior surface of the node; seen from behind broader above than below, with rather sharply rounded superior corners. Ventral surface of petiole when seen from the side with a longitudinally elongated, broadly convex lobe. Legs with all femora distinctly incrassated at the base; tarsal claws slender, distinctly curved, sharp at their tips.

Gaster rather large, elliptical.

Entire body shining. Head and petiole very sparsely and finely punctate; mandibles with more pronounced punctures; pronotum densely and finely foveate-punctate; mesonotum, mesoepinotal impression, and epinotum densely and rather coarsely foveate-punctate. Mandibles, clypeus, front of head, fore coxae, and posterior declivity of mesonotum (near the mesoepinotal impression) with rather coarse, irregular, longitudinal striae. What appear to be striae on the epinotum and the coxae of mid and hind legs are merely internal structures visible through the semitransparent integument.

Hairs yellow; long and pointed on the antennae (sparse and oblique on scapes, rather numerous on funiculi) long, numerous, and clavate with spatulate tips on upper surface of mandibles and on clypeus; long, slender, sharp, and rather numerous on lower surface of mandibles; long, sparse, and clavate-spatulate between upper margin of clypeus and lower margin of eyes; long, slender, pointed, and rather numerous on gula, becoming clavate-spatulate anteriorly; short, pointed, and abundant on palpi; long, slender, sharp, and rather sparse on ventral surface of pronotum, on coxae, petiole, and gaster, and on dorsal, apical margins of fourth and fifth gastric segments; a row of a few long, slender, pointed hairs on ventrolateral margins of petiole, and a row on each posteriolateral margin of epinotum; slender, pointed, and very sparse on trochanters and femora; absent from upper surface, sides, posterior margin, and posterior corners of head, from dorsal surface of thorax and petiole, and from most of the gaster. Pubescence very short, sparse, and indistinct.

General color of body yellowish brown; legs paler; clypeus (except its anterior margin), antennal scapes, and the striated region around the frontal area more whitish; a semicircle of brown extending across the posterior head margin and into the upper eye margins; mandibular teeth very dark brown; median portion of clypeus with a faint longitudinal band of light brown; mandibles, anterior clypeal border, and antennal carinae light brown; eyes distinctly violaceous. Dorsum of pronotum light brown with a V-shaped lighter area medially, the apex of the V pointing forward; dorsum of epinotum light brown; dorsum of gastric segments light brown, basal portion of first segment and lateral margin of each succeeding segment whitish; tarsal claws reddish brown.

*Paratypes*, minor workers.—Combined lengths of head and thorax of each of the 7 specimens are as follows: 1.94, 2.12, 2.30, 2.31, 2.33, 2.33, and 2.33 mm. The minors differ from the majors in the following characteristics: Size smaller; head not rectangular, much narrower anteriorly than posteriorly, its posterior border convex, its posterior corners not angular; eyes much larger in proportion to head size and more bulging; clypeus longer and projecting much farther forward over the mandibles, its anterior border arcuate instead of subtruncate, with a median longitudinal convexity; frontal area, frontal groove, and lateral ocelli much less pronounced; frontal carinae short and indistinct; median ocellus absent; mandibles narrower, greatly arched (that is, their lower surfaces greatly concave) their teeth longer and sharper, the apical tooth especially so; antennal scapes proportionally longer and more slender; mesonotum less convex in profile; dorsal surface of epinotum more flattened in profile, its posterior declivity straighter; a low, longitudinal, keel-like elevation along each dorsolateral margin of the mesoepinotal impression; petiolar node slightly less deeply excized along its superior border; pilosity very scarce and clavate-spatulate hairs absent; colored a more uniform yellowish brown.

*Paratypes*, intermediate workers.—Combined lengths of head and thorax of each of the 15 specimens are as follows: 2.37, 2.40, 2.51, 2.51, 2.51, 2.53, 2.59, 2.59, 2.59, 2.62, 2.62, 2.64, 2.64, 2.69, and 2.69 mm. Resembling the minors except in size; distinctly less bulging eyes; less anteriorly projecting clypeus; narrower mandibles; less broadly

convex posterior head corners and margin; more pronounced frontal carinae, frontal groove, and ocelli; and presence of a few scattered clavate-spatulate hairs on clypeus and gula.

*Paratypes*, major workers.—Combined lengths of head and thorax of each of the 2 specimens are 2.81 and 2.87 mm. Resembling the holotype except for their slightly smaller size and absence of prominent brown areas on head and thorax. The eyes are black in these alcoholic specimens, but they become violaceous when dry.

Described from a series of 25 workers collected by the writer at Jorhat, Upper Assam, India, February 22, 1944. The ants were running up and down on the trunk of a tall tree located in a sunny area beside a rice paddy. They were very agile and ran swiftly with a jerky motion. There were indications that the nest was arboreal, although there was no actual evidence to substantiate this view. The writer spent nearly four hours collecting the series of workers which were extremely scarce. Wheeler (1921, p. 115) states that "the thickened bases of the femora of *G. howardi* indicate that this ant can jump like the large-eyed *Gigantiops destructor* Fab. of the Nectropical Region." The ants which I collected did not jump when they were disturbed but instead veered sharply toward the opposite side of the tree trunk.

Paratypes are to be deposited in The U. S. National Museum, the Museum of Comparative Zoology, at Harvard, and the collection of the author.

*Affinities.* *G. spatulatus* appears to be closely related to *kalshoveni* Wheeler, but it differs from *kalshoveni* in the following distinct characteristics of the major worker: In proportion to its length, the clypeus is much broader and is subhexagonal in shape; the head is more rectangular and possesses more sharply rounded posterior corners and a nearly posterior border; the thorax in profile appears more slender; the mesoepinotal impression is much broader; the posterior declivity of the epinotum is less steep; the petiolar node is much higher and larger, thicker above, less distinctly cuneate, and its superior border is less sharp; there is a darker body color, the mesonotum, episternum, and dorsum of gaster are brown, and there is a brown postocular crescent. Major workers of *spatulatus*, *kalshoveni*, and *chapmani* have clavate-spatulate hairs on the clypeus and upper surface of the mandibles.

*G. spatulatus* differs from *G. luzonensis* var. *chapmani* in the following characteristics of the major worker: The overall size is smaller; the thorax appears more slender in profile; the pronotum and mesonotum in profile are less convex; the mesoepinotal impression is deeper; the metanotum is less marked, not broader than long, and the mesometanotal suture is indistinct; the epinotum in profile is more angular; the petiolar node is higher, much thinner in profile, with a much thinner upper border, sharper corners, and a more deeply excized upper border; and there is a brown crescent above and behind the eyes.

The following key should serve to separate readily the major workers of five of the six known forms of *Gesomyrmex*.<sup>3</sup>

<sup>3</sup>Workers of the typical *luzonensis* Wheeler are apparently unknown.



1. Hairs on front and clypeus bifid or multifid at their tips.....**chaperi** André  
Hairs on front and clypeus not bifid or multifid at their tips; those on clypeus  
clavate with spatulate tips.....2
2. Petiolar node as thick above as below in profile, its superior border rounded  
and entire.....**howardi** Wheeler  
Petiolar node not as thick above as below, its superior border excized.....3
3. Mesonotum distinctly broader than long, very convex in profile, with  
anteriorly curved posterior suture.....**luzonensis** var. **chapmani** Wheeler  
Mesonotum not broader than long, much less convex in profile, with straight  
posterior suture.....4
4. Petiolar node about one and two-thirds times as broad as long, lower than  
the crest of the epinotum.....**kalshoveni** Wheeler  
Petiolar node longer than broad, as high as the crest of the epinotum,  
**spatulatus** n. sp.

I wish to express my appreciation to Dr. M. R. Smith who kindly presented me with references to the genus *Gesomyrmex* in the literature, to Dr. J. Bequaert who sent me for examination types of *G. kalshoveni* and *G. luzonensis* var. *chapmani*, and to Mr. J. W. Jones who checked and verified my description and drawings of *G. spatulatus*.

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# THE BIOLOGY OF MICROVELIA CAPITATA GUERIN, 1857, IN THE PANAMA CANAL ZONE AND ITS ROLE AS A PREDATOR ON ANOPHELINE LARVAE<sup>1</sup>

(Veliidae: Hemiptera)

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## INTRODUCTION

In the course of studies on malarial vectors in the Panama Canal Zone, attention was directed during the dry season to *Anopheles pseudopunctipennis pseudopunctipennis* Theobald. The dry season on the Pacific side of the Isthmus of Panama lasts from about the middle of December to the middle of April. During this period only a negligible rainfall occurs and the countryside becomes very dry with the streams either drying up completely or flowing at an extremely slow rate. For example, the Rio Cardenas, along the Chiva Chiva Trail, about four miles from Balboa Heights, was reduced to a trickle, and its sunny pools became covered with green algae. It was in the still sunny pools associated with the algae that *Anopheles pseudopunctipennis pseudopunctipennis* Theobald was found abundantly. In this same habitat, running over the surface of the water and algae were great numbers of the tiny veliid, *Microvelia capitata* Guerin. Their cast skins were to be seen everywhere on the water and algae. That the *Microvelia* were feeding upon the Anopheline larvae was strongly suggested by this association. A number of collecting trips were made during March, 1945, to collect these small Hemiptera and to study their feeding habits in the laboratory.

No records could be found in the literature of anopheline larvae having been utilized as food for *Microvelia* species. Bueno (1917) found that *Microvelia borealis* Bueno would feed upon daphnia in aquaria but fed them dead or waterlogged insects. Hungerford (1919:138) fed his reared specimens on plant lice and house flies. He added that they do very well if only ostracods and daphnia are in the water. Hoffmann (1924) successfully reared his species of *Microvelia* on a diet of cockroach nymphs thrown into the water upside down to expose the soft underparts. Jordan (1932), in rearing *Microvelia schneideri* Schltz., put crushed adult gnats, midges, and mosquitoes on the surface. For the larger instars he used crushed flies. He noted that the specimens in his aquarium would not accept *Podura aquatica*, which he found abundantly on the ponds where *Microvelia* was plentiful. As far as I know, the studies given below contain the first record of *Microvelia* species feeding upon anopheline larvae.

<sup>1</sup>This paper is a result of some studies of malarial vectors and their predators at the Army School of Malariology, Fort Clayton, Panama Canal Zone, during 1944 and 1945.

## ACKNOWLEDGMENTS

I wish to take this opportunity to express my especial thanks to Mr. Philip Marucci, now with the Cranberry and Blueberry Laboratory, Pemberton, New Jersey, for the initiation of this study. His continued encouragement, optimism, and untiring efforts in assisting with the many problems that arose are sincerely appreciated. To Messrs. George S. Ryan and Wellman Turney I am very grateful for aid in the rearing work and in keeping records when I was not available. To my many associates, while in Panama, I am very grateful for their interest in the problem and I wish to thank them all: Dr. W. W. Middlekauff, now with the University of California, then in charge of the entomological investigations, for helpful advice in the preparation of this paper; Dr. Samuel L. Meyer, now with the University of Tennessee, for identification of the aquatic plants; and Messrs. Ross H. Arnett, Paul K. Adams, Robert Van Doran, George L. Wood, Joseph Griffing, and Robert Olson. I wish to thank Dr. Robert L. Usinger for encouragement in preparing this paper, and for reading the manuscript. His recognition of the scarcity of studies of this nature and of the lack of published records of *Microvelia* sp. feeding on anopheline larvae added impetus to the publication of this paper. I extend sincere thanks to Mr. A. P. McKinstry for identification of the species and to Dr. Edward S. Ross, of the California Academy of Sciences, for curating the material that was presented to the Academy in 1946.

## EQUIPMENT AND METHODS

Although large numbers of *Microvelia* were collected and brought into the insectary in late March, 1945, it was not until April 12, 1945, that the first life history studies were begun in the insectary. The insectary was a screened-in portion of the ground floor of a barracks building. This arrangement allowed almost complete freedom of air movements and during rains accompanied by wind, the insectary floor was wet for eight feet in from the walls, and the air within the room was filled with fine droplets of moisture. These conditions so closely paralleled those of the out-of-doors that it appeared justifiable to correlate the life histories with meteorological data. Data taken at Balboa Heights, Canal Zone, (Marx, 1945), three miles from the laboratory and with about 100 feet difference in elevation, are used. The thunderstorms that occurred in the wet season covered both localities in almost all cases.

Breeding stock was kept in large, shallow, enameled pans about 15 inches by 10 inches in size. Although the alates showed some tendency to escape, few would leave if they were supplied with ample anopheline larvae to feed upon. Larvae of *Anopheles albimanus* Wied. were used exclusively for food, although from time to time small cockroaches and Collembola fell into the water and were attacked greedily. Larvae of *Aedes aegypti* L. were kept in each pan to cleanse the water. As these larvae hung at an angle of at least 45° from the surface, they could not be attacked by the *Microvelia*. When the *Aedes aegypti* pupae were picked out each day, the alate *Microvelia* showed no tendency to fly away, but all ran rapidly to the farthest corners of the pans. Small squares of ordinary filing cards, bits of wood and bark, and leaves of

*Pistia*, *Najas*, *Salvinia*, and *Azolla* spp. were put in the pans. These were used for oviposition, as will be described later. However, the edges of the pans just below the surface of the water were most utilized for egg deposition.

For the individual life history studies, small vials 1 inch in diameter and 13.4 inches in height were used. These were kept about three-fourths full of water. A newly laid egg attached to a small piece of filing card was placed in a vial and the number of days required for the egg to hatch recorded. It was found that the small squares of paper aided the young insects to capture anopheline larvae, providing a place for orientation of the larvae other than the meniscus.

Every day larval counts were made. A few larvae died because of the rather pure water in the vials, but these were easily distinguished from those fed upon by *Microvelia*. The larvae which died naturally usually sank to the bottom, and if not, they were not shrunk in the slightest degree. Those fed upon were shrivelled, greatly shortened, and often twisted into an S-shape. To prevent natural dying in the vials, the larvae were changed at least every other day. Fresh larvae were substituted for those killed to assure a constant daily food supply.

Only first stage mosquito larvae were presented to all of the instars, except the first and second instars of the second, third, and fourth filial generations and to the second instar of the first generation. These smaller instars of *Microvelia*, it was rapidly learned, thrived best on what were termed "pinhead larvae", which were those freshly emerged. After a day or so, these grew larger and were then called "first stage anopheline larvae." It was found that about fifteen pinhead larvae would give the first instar bugs a better chance to find their prey. All the larger instars were supplied with eight first stage larvae daily. The adults were given second, third, and rarely, fourth stage larvae to feed upon.

When alate adults were kept, individually or paired, in the small vials, they had a definite tendency to fly out and escape. To avoid this, loose cotton plugs were used in the tops of the vials. These plugs probably increased the humidity in the vials and stopped the normal air currents. This more humid environment did not seem to increase the length of life of the alate adults, as the apterous individuals and pairs lived as long as did the combinations containing alates.

## DISCUSSION

### *Copulation*

The act of copulation has been adequately described by Bueno (1910) and so will not be repeated here. In eleven cases closely observed for thirty minutes after combining a male and a female, immediate copulation was noted in four, no copulation for at least thirty minutes in six, and one case where the male repeatedly attempted to copulate but was kicked off by the hind legs of the female. In those instances where copulation was delayed, the females varied in age from twenty-four to forty-eight hours, with one being eleven days old. Those females allowing immediate copulation were two, nine, nine, and fourteen days old.

The mating behavior of three pairs that copulated immediately was observed under a dissecting microscope for two and one-half hours in one case and about one hour in two cases. In the first instance the male was placed in the female's vial at 8:30 a.m. They copulated at 8:32 a.m., separating at 8:36 a.m. The male then followed her about closely, keeping his antennae straight forward and constantly jerking nervously. The female allowed the male to mount at 8:39 a.m. and to finish at 8:42 a.m. Although the female moved about the vial, the male continued to remain at her posterior, antennae straight forward, and once in a while let out a series of spasmodic jerks up and down, lasting approximately a second. They copulated again at 8:48 a.m., separating at 8:51 a.m. The male persistently followed her about, and copulation took place again at 9:22 a.m., with his backing off at 9:24 a.m. The last copulation observed took place from 10:28 a.m. to 10:30 a.m. The observations ended at 11 a.m.

The second pair copulated immediately at 9:54 a.m. and did not separate until 10:00 a.m. They repeated the act at 10:34 a.m. but lasted only one minute, again from 10:38 a.m. to 10:40 a.m., and from 10:47 a.m. to 10:49 a.m. The observations were terminated at 11 a.m.

The third pair mated at 10:01 a.m., fifteen seconds after discovering each other. This act required five minutes. At 10:08 a.m. the male attempted copulation, but the female escaped him by running up the side of the vial. He tried once more after she returned to the water surface, but she again ran up the side of the vial and the male fell off backwards. However, matings took place from 10:17 a.m. to 10:20 a.m., from 10:23 a.m. to 10:27 a.m., and from 10:47 a.m. to 10:49 a.m. Observations ceased at 11 a.m.

My movements at the microscope and my shutting off and turning on the light repeatedly seemed to have no effect on the activities of these copulating pairs, not even on the females who seemed to have little interest in the males at times. Those *Microvelia* not mating immediately ran about wildly in response to similar disturbances.

### Oviposition

A survey of the literature shows varying reports as to where *Microvelia* lay their eggs, particularly whether just above or just below the surface of the water. Bueno (1910) found *M. americana* (Uhler) females deposited their eggs on the sides of the aquaria, just above the water surface, but not on the abundant duckweed furnished them. With *M. borealis*, Bueno (1917) found that the eggs were placed on the under surface of duckweed and if this was not available, they were deposited anywhere. In his study of *M. americana*, Hungerford (1919) reported that the eggs were placed as a rule just above the surface of the water on pebbles, jutting stones, and the like. Poisson (1924) was positive in stating the eggs of Veliidae were not immersed when placed on rocks and on aquatic plants, but verified many times that immersion of the eggs did not hinder the embryonic development. Of thirty-five eggs laid by a female of *M. schneideri* Schltz., Jordan (1932) noted that pieces of wood and reed and the floating fruit of *Rumex aquaticus* L. were preferred but gave no indication as to position. He also found that not all of the plants occurring in the natural environment of his *Microvelia* were equally used for egg deposition.

In the present studies, two types of egg-laying environment were provided: one, the confinement of the vials; and two, the broad, open pans. In the vials the females mostly laid their eggs on the edges of the vials just below the water surface, but probably from one-fourth to one-third of the total eggs laid were deposited on the edges of small squares of filing card provided for that purpose. The squares of card were often dispensed with and in such cases all of the eggs were laid on the edges of the vials. The eggs were deposited in an irregular manner. Even when laid in a group, which was unusual, the eggs were not placed

TABLE I  
RESULTS OF DESSICATION TESTS ON *Microvelia* EGGS

Age before dessication, days	Total in each age group	Total showing development before treatment	Total emerging after dessication	Total not emerging	Time from laying to emergence,* days
Dessicated 24½ hours					
1	8	0	0	8	7, 8, and 9 7 and 8 7
2	4	0	0	4	
3	14	2	13	1	
4	9	9	9	0	
5	9	9	9	0	
Dessicated 29 hours					
1	3	0	0	3	8 8 8 8
2	2	0	0	2	
3	9	5	6	3	
4	1	1	1	0	
5	8	8	8	0	
6	6	4†	4	0	
Dessicated 48 hours					
1	14	0	0	14	7, 8, and 9 (one each day)
2	3	0	0	3	
3	4	4	3	1	

\*Time for untreated eggs, 6 to 7 days.

†Two had emerged just previous to dessication.

in any discernible pattern. Usually the eggs were scattered around the circumference of the vials, apparently having been deposited individually and at different times.

In all of the rearing records for the vials, only one female was found that laid an egg above the water line exposed to the air, and she placed only one egg on the edge of a vial. Six females deposited eggs free on the surface of the water and their respective totals follow: 1, 3, 2, 1, 2, 1.

The placing of eggs on dead anopheline larvae was more common, and eleven females were recorded as doing so. Their respective totals are: 10, 8, 4, 1, 3, 12, 8, 9, 8, 29, and 4. These eggs were laid along the sides of the larvae and always below the surface of the water. The remainder of the more than four thousand egg depositions observed in the vials were laid on the edges of the vials or on the card squares.

In the open pans small squares of filing cards, bits of wood and bark, dried leaves, and small plants of *Pistia stratiotes* L., *Salvinia natans*, *Azolla filiculoides*, and *Naias* sp. were placed on the surface of the water. Although no quantitative results were obtained, definite preference was shown for the dried leaves of the various plants and the card squares. The living leaves of *Naias*, *Pistia*, *Azolla*, and dried twigs came next in preference, while *Salvinia* and dried grass blades were almost unused for egg deposition. Only 5 of 381 eggs were deposited on the upper surfaces above the water line. Two of these eggs were on living *Pistia*, two on living *Azolla*, and one on a dried twig. Otherwise, the eggs were placed along the edges on the under sides of the leaves and twigs beneath the water surface. It was soon discovered that the majority of the eggs were laid around the edges of the pans just below the water surface. The level of the water went down due to evaporation, but more was added daily and the eggs were not harmed if exposed less than one day at a time. When all debris and plants were taken from the pans, the edges were used exclusively for egg laying, except for an occasional few on a dead anopheline larva floating at the surface.

*Notes on air-dried eggs.* To check the emergence of eggs exposed to the atmosphere, three tests were conducted which are reported in Table I.

From the results given, it appears that most eggs three or more days old before being subjected to dessication were able to survive and emerge. The younger eggs collapsed upon drying but regained their turgidity when re-wet. However, they always failed to develop. The time for embryonic development was lengthened somewhat by drying.

Two cases were observed, however, in which the squares of card bearing the eggs were pulled about one-half inch above the water line in the vials by cockroaches. These eggs were, in each case, dried for about twenty-four hours, two days after laying. Of the five so treated, all were fertile and hatched. The elapsed time from laying to emergence was six and seven days, the same length of time as for all other eggs kept moist.

That these latter five eggs hatched while others the same age did not, probably can be explained by the fact that the eggs mentioned in Table I were completely removed from any moisture or water surface and the card squares were dry when used to scrape the eggs from the edges of the vials. The latter five were just above the water in the vials where the air was supposedly nearly saturated and the card squares were waterlogged and took some hours to dry out. This suggests that complete air drying may be fatal to the more immature eggs, while they can withstand the normal humidity above a water surface, as would be the case in nature.

*Oviposition patterns.* Table II is a compilation of a number of records concerning oviposition and fertility of the adult females.

It will be noted that the females whose mating was delayed laid comparatively few eggs. The first eggs never appeared before the fourth

TABLE II  
OVIPOSITION PATTERNS AND FERTILITY OF MATED AND UNMATED FEMALES

AGE OF ADULTS WHEN MATED, DAYS		INFERTILE EGGS LAID PRIOR TO MATING	CONDITION OF FIRST EGGS AFTER MATING			FERTILITY RECORDS		
♂	♀		Time following mating, days	Total laid	Fertility of first eggs	No. of eggs observed	Total infertile	Time over which eggs were laid, days
First generation								
3*	0†	0	6	1	0	33	33	30
4	0	0	2	2	2	32	0	42
0	1	0	4	17	17	50	0	11
1	1	0	1	2	2	33	0	6
11	5	0	1	4	4	32	0	25
12	8	0	1	6	6	42	0	55
5	9	3	1	9	9	14	0	4
8	9	13	1	15	15	34	0	42
10	9	5	1	12	6	16	6	2
8	11	9	1	9	9	18	0	30
14	15	17	1	14	14	22	0	2
Second generation								
0	0	0	3	4	3	101	5	62
2	0	0	2	2	2	165	6	73
1	1	0	1	2	2	61	2	27
3	2	0	1	2	1	91	4	31
Third generation								
0	0	0	2	2	2	64	6	66
1	0	0	3	8	8	105	2	58
1	0	0	2	3	3	42	2	52
5	0	0	4	1	0	26	1	19
			5	5	5			
11	0	0	5	3	2	34	2	36
Unmated females								
	0		4	1	0	184	184	37
	0		4	1	0	59	59	27

\*The male died two days following combination.

†The 0 signifies the specimen was mated as soon as it became an adult.

or fifth days after emergence, and it seemed as though the females were holding back since their abdomens were greatly and continually swelled.



After mating, these same females tended to lay great numbers of eggs immediately, with a surprisingly large number fertile. The females that were mated as soon as it was discovered they were adults did not lay any eggs for a period of from two to five days. It is to be presumed that this period was needed in which to mature the eggs before any oviposition could take place.

The largest number laid in any one day is the 17 shown in Table II. Ten, eleven, or twelve eggs were common maxima recorded in the daily records, with greater totals being rare. The females showed a tendency towards periodicity in their laying. A gradual building up to the maximum would occur over a period of four, five, or six days during which period few eggs were laid each day. The females' abdomens would gradually swell during this interval until they actually bulged and then there would be a large number of eggs laid and the cycle repeated. The greatest number of eggs was produced during the first three-fourths of the females' life, with the dwindling of egg production heralding the approach of death.

*Fertility notes.* All the fertility figures in Table II are from daily lots of eggs scattered throughout the life of the mated females. These were observed carefully for emergence percentages. Fertility did not tend to drop as death approached, the infertile eggs being scattered throughout the lives of the females involved. It is not deemed significant that the infertile eggs were fewer in number in the first generation. For this generation, fewer records were kept and the chances of finding an isolated infertile egg were thereby reduced.

The fertility of the females ceased soon after the death of the males. The records are but four in number but indicate that fertility lasted at most four days—in one case only three—following death of the male. It is true that the females were near the end of their lives, but in seven out of eight cases in which the females died first, even the very last eggs laid were fertile. The exception involved five eggs laid the day a female died, of which two were infertile.

The first pair of adults recorded in Table II never produced any fertile eggs. The male died two days after confinement with the female. She was newly emerged and probably not ready for copulation. The male either died before the female allowed copulation, or if copulation did take place, the sperm were viable for only a short time. In accordance with this latter possibility, other paired adults were seen in copulation from time to time in the vials, indicating frequent copulation was necessary to maintain fertility.

Only two experiments were conducted to gain some idea of the fertility of eggs in relation to the length of time after copulation. The results are not reported in Table II but are given here. In one case, the female was two days old and the male six. They were mated for two hours and then separated for seven days, during which time the female laid twenty-five eggs. Twenty-one, laid throughout the seven days, were checked for fertility and all were fertile. Oddly enough, the day following permanent re-mating, eight days after the first mating, three eggs were laid of which two were infertile. In the second case, the female was two days old and the male six. Mating was allowed for two and one-half hours and then the male kept separately for eight days.

The female produced a total of twenty eggs. Twelve were watched carefully for fertility, some being taken from each day's laying, and all were found to be fertile. As in the above case, the day following remating, this female produced the same proportion of infertile eggs, eight out of twelve. Infrequent subsequent checks on the fertility of the eggs from these two females showed that they laid no additional infertile eggs. The results of these two tests were unexpected, and the author is unable to offer any explanation of the observed data.

#### *Incubation Period*

Various lengths of time for egg development have been recorded in the literature. Bueno (1910) reported 17 days for *M. americana* and (1917) 7 to 23 days for *M. borealis*, with 7 days for his controlled experiment of three specimens. Hoffmann (1925) found 18 days for *M. borealis* and 10 to 12 days for *M. buenoi* Drake. Hungerford (1919) found the time to be around 6 days in July for *M. borealis*.

In all cases, the incubation period for *M. capitata*, regardless of season, was from 6 to 7 days. As the temperature was rather constant throughout this study, it is believed that the temperature of the water had quite an effect upon the embryonic development. Temperature differences may account for the different incubation periods reported above.

#### *Emergence*

Three observations on emergence from the egg were recorded, two in which the eggs were submerged and one with the egg at the water surface. Although looked for under a binocular microscope no post-natal molt was seen. Bueno (1917) did not find this "amnion" but Hungerford (1919:38) definitely did. It could be missed very easily, as Hungerford pointed out that the membrane has to break before the antennae, legs, and beak are free. In the notes given below, it appears as though the molted membrane remained in the egg, and that probably accounts for its not being seen.

The first emergence began at 9:28 a.m. The body was pale yellow, the eyes red, and the appendages white with the joints black as the bug pulled free from the egg. The egg was submerged, and when the nymph touched the surface with its leg, the whole body broke through and it lay flat on the surface. At 9:30 a.m. the legs were strong enough to support the body above the surface. The tiny bug rested for three minutes and then began to rub all the appendages against each other and against the body. At 9:41 a.m. the body was darker and at 10:00 a.m. when the observations terminated, the body was blackish-gray and the legs gray.

The second emergence began at 3:22 p.m., the whole colored mass moving slowly downward from the egg. It looked as if the whole egg were moving. After the insect was completely free from the egg case, the antennae, followed by the legs, spread, opened out, and become functional. This egg was just at the water surface, and the tiny bug at no time touched the water before its legs were functional. No post-emergence molt was noted, even though it might appear that the membrane was shed outside the egg and above the water surface. The bug rested until 3:40 p.m., occasionally moving an appendage slowly.

TABLE III  
DAILY RAINFALL AT BALBOA HEIGHTS CORRELATED WITH LIFE HISTORY STUDIES

April, 1945

Day of the month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
Number of life histories started (emergence from egg)												9	3	1		9		23	8	1	2		3	2							
Number attaining adulthood																															
Daily rainfall in inches						T								T	.01		.12						T	.11		1.02	.18	T			.40
Number of <i>Micronetia</i> dead each day																	1						5	4	4	4	1	1			
Instars of those dead (1=first, 2=second, etc.)																	1						2	1	2	2	3		3		

May, 1945

Day of the month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Number of life histories started (emergence from egg)											2	7		15	8	7	3	1		1											
Number attaining adulthood	5	5	2	5	5	3	6	6	5																						1
Daily rainfall in inches	.07	.64	1.07	.06					.10	.78	.15		T				.01		.02			.02				.44	.08	.07	.09		.62
Number of <i>Micronetia</i> dead each day			1	1	1	2	1							2	1	3	1	3	1		2		1		1	2					
Instars of those dead (1=first, 2=second, etc.)			4	5	A†	5								1	1	1	1	1	2		1		2		2	2					

†Second and third days of adult life.



The last emergence began at 2:10 p.m. The insect pushed its way out of a long slit in the egg by enlarging and contracting the body. It was all out of the egg after a final swelling and rested at 2:12 p.m. At 2:13 p.m. the appendages came free from the egg and the bug rested again until 2:18 p.m. At this time, it began to pull itself free from the water and to break out of the surface film. The insect would rest and struggle alternately. The antennae were freed first and then the front and middle legs, following which the head was lowered almost to the water and the abdomen raised. From this position, the hind legs were pulled free of the water and dried. The insect was completely through the surface film at 2:20½ p.m., after which it cleaned the appendages by rubbing them against each other until 2:22 p.m. One hind leg was actually put as far forward as the eye during the cleaning. At 2:22 p.m. the insect began to run about actively.

Sometimes when transferring eggs from the sides of a vial to a card square, the eggs would not stick to the card and would sink to the bottom of the vial. Of 29 eggs watched on the bottom, all emerged, although they had sunk not over 24 hours after oviposition. The exact time of hatching was unknown, but not over 24 hours elapsed in any case before they were observed after hatching. Eighteen tiny *Microvelia* were found walking about on the bottom or sides of the vials. One was definitely known to reach the surface, but none seemed to exhibit any negative geotropism and climbed straight up the walls of the vials. Eleven of the tiny insects had drowned and were lying dead upon the bottom.

#### *Postembryonic Development*

The developmental periods recorded in the literature vary in duration. Bueno (1910) gives from 22 to 31 days for *M. americana* and (1917) from 15 to 49 days for *M. borealis*. Other records include the following: Hoffmann (1925), 22 to 27 days for *M. borealis* and 26 to 37 days for *M. buenoi*; Jordan (1932), 33 days for *M. schneideri*; and Poisson (1924), 23 days as the average time for *M. pygmea* Duf. All of these records appear to be from *Microvelia* reared under artificial conditions.

Hoffmann (1925) pointed out that, "Inasmuch as temperature plays such an important role in the development of these forms, the rate of development at unknown temperatures is not extremely valuable." As was mentioned in the introduction to this paper, the laboratory conditions under which the present life history studies were carried out so closely paralleled those of the natural environment that some conclusions appear justified, and these follow.

*Correlation with climatic data.* Daily rainfall totals for the months of April, May, June, July, and August are shown in Table III while monthly averages of temperature, temperature range, and evaporation for these same months are given in Table IV. These data (Marx, 1945) are for Balboa Heights, Panama Canal Zone, three miles from the laboratory.

TABLE IV  
METEOROLOGICAL DATA OF BALBOA HEIGHTS, MONTHLY AVERAGES

Month	April	May	June	July	August
Mean temperature, degrees F...	85.4	81.5	83.6	80.3	81.4
Maximum temperature, degrees F.....	95.0	92.0	93.0	92.0	91.0
Minimum temperature, degrees, F.....	73.0	73.0	74.0	73.0	73.0
Daily mean range, degrees F...	17.2	12.6	12.1	12.6	12.0
Total rainfall, inches.....	1.84	4.22	5.17	5.89	6.37
Evaporation, inches.....	5.431	3.451	2.468	2.386	2.358

These tables also show the starting dates of each life history, and the day and instar that each specimen died or grew to an adult. Sixteen first stage nymphs died, 14 seconds, 15 thirds, 5 fourths, 11 fifths; and 2 adults died two days after the last molt. Although the smaller instars appeared to be more susceptible to adverse conditions, enough of the larger ones died to make it appear as if humidity had some effect upon the death rate.

A check of daily rainfall totals with the number of deaths seemed to indicate some correlation between these two phenomena. It may be noted here that the thunderstorms passed over from noon to later in the day, while most of the observations were made during the mornings. This would account for deaths occurring on the same day as heavy rains. During April, deaths fell off following the heavy rain of the 26th. In May, deaths did not decrease after the rain of the 4th but were otherwise most numerous during the dry mid-month period, a rain of 0.44 inch appearing to halt further deaths while rains on May 31, June 1, and June 3 continued to halt dying. The only other heavy rain, on June 7, seemed to have a lasting effect, although there was some break between generations at that time. The records for July and early August tend to show the same trend. Nothing positive is indicated by these data, but it is suggested that the *Microvelia* may not be able to withstand dry conditions as well as humid conditions.

Temperature probably entered in here also, and it is to be regretted that no daily temperature records could be obtained. However, the temperatures were quite constant, except for April, which was noticeably hotter, and for June, which may account for the great number of nymphs dying in the latter month. Air humidity, as shown by the evaporation of water in inches, was rather constant for the wet months. April's figure was very high as a result not only of lack of rainfall but also of the strong dry north winds that blew so regularly in the dry season. These winds subsided in early May and there was little air movement during the wet months of June, July, and August.

Table V gives a summary of the average length in days of all stages in the life history.

TABLE V  
RESULTS OF LIFE HISTORY STUDIES BY GENERATIONS

GENERATION	MONTHS	AVERAGE DURATION OF EACH STAGE						TOTAL DEVELOPMENTAL PERIOD
		Egg Stage, days	First Instar, days	Second Instar, days	Third Instar, days	Fourth Instar, days	Fifth Instar, days	Average number of days
First.....	April-May	6.5	5.1	4.9	3.2	3.2	3.7	26.6
Second.....	May-June	6.5	5.6	3.1	2.7	2.8	3.5	24.2
Third.....	June-July	6.5	2.5	2.5	2.9	3.0	3.3	20.7
Fourth.....	July-Aug.	6.5	2.2	2.2	2.7	3.1	3.7	20.4

The average number of samples used for any instar of each generation was 28, while the minimum was 16 and the maximum 41. The duration of the egg stage remained constant throughout. During April and May, the drier period, the life histories required more time with the first and second stadia showing the greatest increase in duration. The last two generations taking place during rainy months are approximately equal in duration. It is believed that the differences in rate of development are a result of the various climatic conditions encountered. The first generation took place under a hot, dry, and windy environment; the second, during a transition period between the two extremes, while the third and fourth took place during the slightly cooler, humid, and nearly windless period.

*Feeding records.* The number of anopheline larvae fed upon by the various nymphal stages is summarized in Table VI.

TABLE VI  
NUMBER OF ANOPHELINE LARVAE UTILIZED FOR FOOD DURING THE  
DEVELOPMENTAL PERIOD

GENERATION	AVERAGE NUMBER OF ANOPHELINE LARVAE FED UPON BY EACH INSTAR				
	First Instar	Second Instar	Third Instar	Fourth Instar	Fifth Instar
First.....	9 1st instar	14 pinhead	14 1st instar	14 1st instar	16 1st instar
Second.....	15 pinhead	16 "	15 " "	16 " "	17 " "
Third.....	14 "	20 "	15 " "	13 " "	15 " "
Fourth.....	20 "	19 "	15 " "	15 " "	17 " "

The tiny pinhead larvae proved to be more of the size required by the small first and second stage nymphs, although the first stage nymphs of the first generation were able to capture and kill large first stage anopheline larvae.

The appearance of the attacked anopheline larvae is given in the introduction. However, some larvae were fed upon to a greater degree than others, and some *Microvelia* had a tendency to feed a little upon one larva, and leave it to search for another before finishing the first. In

this way, large numbers of larvae were killed, but their contents were not completely consumed.

It was found, in making up this summary, that if a nymph fed a great deal as one instar, it would take less food as the next, and vice versa. The majority of the totals of larvae fed upon in each instance tended to be close to the averages, while extreme deviations were few in number.

*Life histories with only four instars.* The number of nymphal instars has been known to vary since 1917 when Bueno found only four for apterous forms of *M. borealis*. Hungerford (1919:139), working with *M. borealis*, usually found four but noted that there were five in some. He suggested that the difference might be due to variation or to the apterous forms having fewer stages than the winged. Five species are known to have five instars, even in the apterous condition. These are *M. americana* (Bueno, 1910), *M. pygmaea* (Poisson, 1924), *M. schneideri* (Jordon, 1932), *M. hinei* Drake and *M. albonotata* Champion (Hoffmann, 1925). Hoffmann repeated Bueno's work with *M. borealis* and confirmed the presence of four instars. This same author found only four nymphal stages in *M. buenoi* also. He found the number of instars constant throughout his studies.

In the present study, 110 life histories were reared from egg to adult in the four generations, of which 76 were apterous. The sexes were about equally divided throughout. Only 9 of the apterous forms had four nymphal instars, and 8 of these were male. Table VII gives a summary of the duration of the stadia.

TABLE VII  
LIFE HISTORIES OF MICROVELIA HAVING ONLY FOUR NYMPHAL INSTARS

GENERATION	SEX OF SPECIMEN	AVERAGE DURATION OF EACH INSTAR				TIME FROM EMERGENCE TO ADULT, days
		First Instar, days	Second Instar, days	Third Instar, days	Fourth Instar, days	
Second*	♂	4	4	3	3	14
	♂	3	5	3	3	14
Third†	♂	3	2	5	4	14
	♂	5	3	6	4	18
	♂	3	3	2	6	14
	♂	3	2	5	3	13
Fourth‡	♀	7	2	2	3	14
	♂	5	2	2	5	14
	♂	3	3	2	6	14

\*The second generation had a post-embryonic period of 17.8 days for those with 5 instars.

†The third generation's period was 14.2 days.

‡The fourth generation's period was 13.9 days.

The length of the life histories was rather close to that of the over-all average, the exception being the second generation, where those with four instars completed their development in almost four days less than the average. Comparing the length of each stage with the averages given in Table V, we find some of the stadia here to be of slightly longer duration to make up for the lack of one complete stage.



TABLE VIII

LENGTH OF LIFE, FECUNDITY, AND FEEDING DATA OF MICROVELIA ADULTS

SEX OF SPECIMEN	TIME LIVED, DAYS	TOTAL EGGS LAID AFTER MATED	EGG-LAYING PERIOD IN DAYS	AVERAGE NUMBER OF EGGS PER DAY	TOTAL ANOPHELINE LARVAE KILLED AND FED UPON, BY INSTARS			
					First	Second	Third	Fourth
First generation								
Alate male.....	44					89	38	
Apterous female..	44	237	33	7.2		96	32	
Apterous male....	67					Incomplete		
Alate female.....	73	324	65	5.0		61	111	
Alate male.....	53				111		52	
Apterous female..	54	253	46	5.5	114		52	
Alate male.....	82					126	104	
Apterous female..	79	283	76	3.7		101	104	
Alate male.....	82					121	116	
Apterous female..	46	179	37	4.8		119	29	
Apterous male....	52					Incomplete		
Alate female.....	36	139	25	5.6		110		
Alate male.....	86				150		134	
Apterous female..	72	376	70	5.4	128		95	
Alate male.....	46					109	18	
Apterous female..	49	226	44	5.1		94	35	
Second generation								
Alate male.....	93					207		
Apterous female..	75	505	74	6.8		177		
Alate male.....	64					163		
Alate female.....	64	392	63	4.6		163		
Apterous male....	60					160		
Alate female.....	35	195	33	5.9		90		
Apterous male....	43					102		
Apterous female..	32	173	31	5.6		73		
Third generation								
Apterous male....	51						126	
Apterous female..	44	163	40	4.1			98	
Apterous male....	63						143	
Apterous female..	63	434	62	7.0			138	
Apterous male....	71						89	
Apterous female..	68	242	67	3.6			89	
Apterous male....	57						87	
Apterous female..	62	427	55	7.8			100	
Apterous male....	46					12	86	
Apterous female..	53	187	41	4.6			109	
Unmated specimens								
Apterous female..	41†	184	37	4.9			118	
Apterous female..	31	59	27	2.2			87	
Apterous male....	72							119
Apterous male....	67							116

†Escaped.

It may be noted that no individual appeared in the first generation with only four stages. Just why this should be is not clear. If the confinement of the small vials had any effect upon the number of stages, why did not those with only four appear in the first generation? This phenomenon as presented here does not answer Hungerford's suggestions, although the variation is apparently restricted to the apterous forms and almost entirely to the male sex.

#### *Activities of the Adults*

*Length of life.* Bueno (1910) and Jordan (1932) have reported the adults as the overwintering stage in America and Europe, respectively. Bueno kept a female in his aquarium from October 2, when it emerged, to its death on December 31, and two males from October 2 into January. In the author's studies, only one male lived as long as Bueno's female—93 days—while most of the adults lived a shorter period, as shown in Table VIII.

It is very probable that Bueno's and the author's figures represent approximately the maximum duration of adult life under warm conditions. Both under artificial conditions and in the tropics, there would be no necessity for a long hibernation period during the winter.

It was often noted that the mated adults would die within three to seven days of one another. This does not show clearly in the table, as very often one individual was kept singly for a time before mating. In only two cases did both individuals die on the same day.

The egg totals given in Table VIII are those laid during mated life and do not include the scattered few that might have been laid prior to mating. The total number of days during which the eggs were laid includes only the days from pairing until death of either partner. As was discussed under "Oviposition," the egg production tended to decrease somewhat as the females grew older. The average number of eggs per day showed some variation, some fertile females being significantly lower in production than one of the unmated females. The unmated female that escaped possibly did so before age cut down on her daily laying totals. The other unmated female produced very few eggs and her record is more like those of the females before they were mated (see Table II). However, egg production does not appear to be associated entirely with reproductive activity. The unmated females seemed to be inhibited in egg laying, depositing comparatively few eggs, while their abdomens remained greatly distended.

Of the 17 females listed in Table VIII, seven died with their abdomens greatly swollen, probably due to eggs that never were laid. Four died with their abdomens quite swollen, five moderately swollen, and one not swollen at all. Usually the condition of the abdomen remained unchanged for a period of three to six days prior to death. It appeared that some females could not lay the last eggs contained within them.

*Feeding records.* The feeding records in Table VIII include the total anopheline larvae fed upon throughout the individuals' lives, whether mated or not. The total number of larvae utilized for food by the mated pairs was divided in half, and each half considered as killed by each adult. As pointed out earlier, the degree to which the larvae were sucked dry of their body fluids varied greatly, but most larvae were badly shrunk and only a few hardly fed upon. In each case where

larvae of more than one instar were presented, the total number of larvae fed upon by an individual is a combination of the instar totals in the table. Of the individuals fed larvae of only one instar, the averages are 3.0 second stage larvae per adult per day, 2.0 third stage, and 1.7 fourth stage.

#### *Miscellaneous feeding notes*

*Upon anopheline larvae.* It was often observed that when an anopheline larva rose to the surface and disturbed the surface film beneath a *Microvelia*, the *Microvelia* would immediately react and explore the movement with its proboscis. Often when touched, the larvae would wriggle to the bottom. It was thought that the bugs were more startled than hungry in these cases.

Only one case was observed in which a larva was attacked and fed upon from the beginning. The *Microvelia* stood over the fourth instar larva and jammed her beak into it at the sixth abdominal segment. She held the integument firmly with the tip of the beak and with the stylets fed on the internal juices. The larva was not lifted from the water at any time. The beak was bent readily at the membrane between the second and third segments as she fed. The stylets could be, and were, extended for a distance slightly exceeding the anterior tibiae in length from the end of the proboscis. The stylets kept up a continuous searching and whipping action, searching here and there within the body for liquids. The larva was shrunken lengthwise upon the extraction of body fluids. The stylets were exceedingly flexible and were capable of being curved into a complete loop, which was observed twice. The male kept bothering the female during this period, trying to get some food, too, but she kept moving her posterior end towards him and kept moving away also.

Only one other observation was made while a *Microvelia* fed and this was a first instar nymph with a first stage anopheline larva speared on the end of its proboscis. The proboscis was held straight out in front of the head with the larva clear above the water.

*Upon other insects.* During the dry season, six Collembola were found in the vials with their contents sucked out. Probably these Collembola were attracted to the water in the vials and were attacked immediately upon reaching it.

Two first instar cockroaches, *Periplaneta americana* L., fell into separate vials and each was sucked dry of its body fluids. The *Microvelia* were second and fourth instars, respectively. Numerous cockroaches of the smaller instars were thrown into the breeding pans. The *Microvelia* would keep at a safe distance until the cockroaches were drowned and then congregate around the bodies seeking to suck out the body fluids.

*Upon Microvelia eggs.* In only two instances were females found sucking the fluid contents from their own eggs, one with a partially developed embryo in it. The eggs were not lifted out in front of the body, but were kept on the water surface. There was no evidence found that this was a usual practice as the eggs not removed from the vials would develop normally and those that did not never appeared emptied of their contents. Possibly more eggs would have been utilized for food if the adults had not been so well fed.

*Upon immature Microvelia.* Of all the 202 eggs that hatched in

seven vials with seven pairs of adults, no nymph was ever attacked and fed upon by the adults. A single record of an adult, a male, feeding upon a first instar nymph occurred during the open-pan experiment (see below). The adults were probably hungry from a scarce food supply and the nymphs were six days old, presumably without food, and so were weakened, if not near death. How many young would be killed for food by the adults under natural conditions is unknown, but it appears that well-fed adults have no interest in their young as a food source.

*Upon other Microvelia adults.* Adults did not seem to be able to attack and kill other adults. Only in a single case was an adult attempting to pierce the integument of his recently dead mate. He approached the carcass, put his proboscis straight out in front, and attempted to pierce it. When unsuccessful, he tried successively different places, but never with any success. The integument always seemed to be too tough. Even when four or five adults were crowded into a small vial for a week or two, none was ever killed.

*Upon anopheline eggs.* Two fifth instar *Microvelia*, one of each sex, were placed in a vial with 27 *Anopheles albimanus* eggs. After two days, two eggs hatched and one larva was fed upon. The eggs were thereupon changed and 55 added. The next day seven had hatched and the seven larvae were fed upon by the *Microvelia*. These were removed and fresh eggs substituted. The male died after six days, not molting. Following this, the eggs were changed daily to prevent hatching. The female died after eleven days of such treatment, still in the fifth stage. Anopheline eggs definitely did not seem to be utilized at all for food, possibly because the *Microvelia* did not readily recognize food that was not active.

*Feeding in a large, open pan.* To test if *Microvelia* could find and capture anopheline larvae in broad expanses of water as well as in the little vials, a pan with a water surface of 8 by 12 inches was used. Two apterous adults were employed and six fourth instar larvae were provided. Every day the number of dead larvae was checked, the larvae were removed and enough added always to keep six in the pan. The two adults killed and fed upon ten fourth stage larvae and one pupa in the 14 days this experiment was continued, a total far below those recorded for adults with ample food supplies in the vials. During this period, numerous eggs were laid and 20 nymphs emerged before closing the experiment. None of the nymphs, which hatched six days before the termination, was seen feeding, although they could have fed upon the larval remains discarded by the adults. It was concluded that *Microvelia* can track down, find, and kill larvae over a large water surface. These results led me to believe that anopheline larvae form a natural food for *Microvelia capitata* in its native habitat.

#### *Wing Development*

Bueno (1910) mentioned that the phenomenon of aptery is displayed in a very marked degree by *M. americana*, but that it was possible to find a few winged individuals in sheltered spots, under overhanging banks, or in exceptional seasons or situations. He added that in the tropics winged individuals were more abundant, adding that Hope had found almost all winged forms of *M. pulchella* Westwood on the Island

of St. Vincent. In his life-history study of *M. borealis*, Bueno (1917) made no mention of alate forms, while Hungerford (1919:137) stated that he found this same species in Kansas in both the apterous and winged state. In Plate XII, Hungerford figured apterous and alate forms of both sexes. He made no statement concerning the relative abundance of each form. Hoffmann (1925) was convinced that Hungerford reared *M. hinei* rather than *M. borealis*.

Jordan (1932) found that winged forms occurred in *M. schneideri*, but that all of the progeny of one alate and one apterous parent always gave apterous progeny. He stated that this result was the same as that obtained in rearing *Hydrometra* and *Mesovelis*.

Poisson (1924) found the apterous form of *M. pygmaea* to be more common in the Norman region. Attempting to find reasons for the two forms, he found that the apterous form appeared "pure" and that the development of the wings was an hereditary character (p. 297) and added (transl.), "The direct action of the factors of nourishment and temperature do not appear to enter into action as 'determinants' of wing polymorphism." He even went so far as to suggest that the apterous form probably had the value of a "new-born" species (p. 272), based upon the fact that the genital segments were larger in the apterous forms than in the alates. However, he could find no size or other variations in the copulating organs of the two forms. Poisson had not verified experimentally if the crossing of the two forms was possible (p. 270) but based his conclusions on the facts he observed in the Gerridae and Hydrometridae. He added, "One is led to suppose that the non-mixing could be total between the two forms of *M. pygmaea*." Lending weight to his conclusion, he added that he never found an alate in a locality of apterous forms.

The results found for *M. capitata* do not seem to bear out Poisson's conclusions. The intermingling of alate and apterous forms was so complete that his ideas of two species arising from the two forms is not considered applicable here at all. When brought into the laboratory, slightly more than one-half of the adults were alate. This nearly fifty-fifty ratio was maintained for eight months in the open pans, from the height of the dry season into the wettest months. The *Microvelia* were not exposed to direct rain, but did receive a fine mist during thunder storms.

In contrast to that ratio, Table IX shows how wing development receded with each successive generation, except the last.

TABLE IX  
WING DEVELOPMENT BY GENERATIONS WITH SPECIMENS REARED  
INDIVIDUALLY IN SMALL VIALS

GENERATION	WING PATTERN OF ADULTS AND FIFTH STAGE NYMPHS, TOTAL IN EACH GROUP			
	Alate Male	Apterous Male	Alate Female	Apterous Female
First.....	14	9	15	16
Second.....	8	13	2	14
Third.....	0	17	1	9
Fourth.....	3	8	0	7

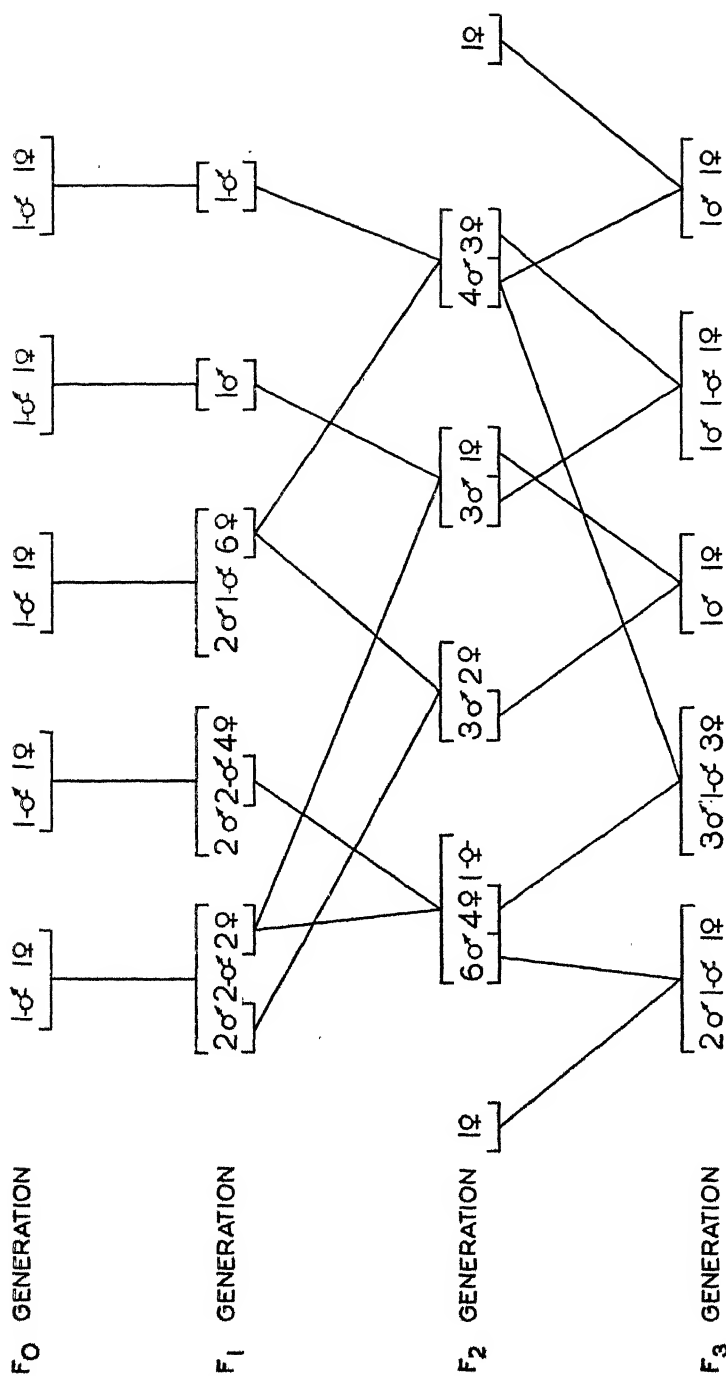


FIG. 1. Wing development within the filial generations. Each line represents a particular individual chosen for a parent for the next generation from the box at the upper end of each line.

The first generation shows a few more alates, and probably represents the proportions of those forms to the total when brought in from the field. The totals are the combined records of adults and fifth-stage nymphs that did not become adults but whose sex and condition could be easily told.

Figure 1 gives the wing development of the filial generations only. Beginning with five mixed pairs, aptery continued to increase until the  $F_3$  generation, when three alate males appeared as progeny of apterous parents. It may be noted that the only alate form to appear in the  $F_2$  generation was from alate parents, which may or may not be genetically significant. Due to a large number of deaths occurring towards the end of the third generation, it was necessary to introduce two females from the breeding pans to increase the total number of mated pairs. The progeny of these two females probably should not be considered. However, those progeny do not change the ratio of alates to apterous forms when included in the total.

Two possible reasons for the increase in aptery suggest themselves. One is the confinement provided by the vials. In enclosed situations, the *Microvelia* possibly encounter some factor that inhibits wing development. On the other hand, crowded quarters might make for wing development so that the specimens could leave the confined environment.

The other reason involves the over-feeding of the developing stages. With an abundance of food always at hand, it is possible that wings are not necessary to carry the individuals to a more provident environment. Therefore, wing development may lag in the presence of ample food. That food may not be the deciding factor is given impetus by the fact that the *Microvelia* in the breeding pans were provided with large numbers of anopheline larvae daily, not to mention such cockroaches, flies, etc., that fell into or were thrown into the pans. As mentioned above, the alate forms comprised at least one-half of the total in the pans throughout the experiment.

#### SUMMARY

The semiaquatic veliid, *Microvelia capitata* Guérin, was found abundantly during the dry season in sunny drying streams in the Panama Canal Zone. In the same association, larvae of *Anopheles pseudopunctipennis pseudopunctipennis* Theob. were plentiful, suggesting that the predatory *Microvelia* fed upon the larvae. Subsequent laboratory studies showed *Microvelia capitata* to be an active predator upon anopheline larvae and four generations were successfully reared using only anopheline larvae for food. Other food was greedily accepted and included immature cockroaches and Collembola.

Life history records were kept daily through four generations, extending from the middle of April, in the dry season, to the middle of August, well into the wet season. The duration of the egg stage varied from six to seven days, regardless of season. The postembryonic period, with five nymphal stages, varied with the seasons, requiring an average of 20.1 days in the dry season, 17.7 days during the transition period, and 14.2 and 13.9 days for the two generations in the wet season. The temperature was highest for the first generation and the humidity much lower. These two factors seemed to be responsible for the

increased duration of the first two generations. The first two nymphal instars in particular and the third to a slight extent were lengthened by the warm, dry conditions. Of 110 complete life histories, 76 were apterous. Eight apterous males and one apterous female had only four nymphal stages. The duration of these four-stage life histories averaged 16.5 days.

The *Microvelia* were fed larvae of *Anopheles albimanus* Wied. Tiny freshly emerged "pinhead" larvae were given the first and second stage nymphs, and large first-stage larvae to the third, fourth, and fifth stage nymphs. The first stage averaged 16 pinhead larvae each, the second stage 17, the third stage averaged 15 first-stage larvae each, the fourth stage fourteen and one-half, and the fifth 16. Anopheline larvae seemed to constitute a natural food source.

Thirty-seven adults, seventeen mated pairs and three single specimens, were fed until they died naturally. The maximum length of life for the males was 93 days and 79 for the females, while the minimum was 43 for the males and 31 for the females. The majority averaged from 50 to 80 days. The adults fed upon large numbers of anopheline larvae. Many of the adults were given larvae of more than one instar throughout their lives, but there are some records in which the adults fed exclusively upon one instar. These averages per day per adult are 3.0 second stage anopheline larvae, 2.0 third, and 1.7 fourth. The egg production records were kept for each female. The average for mated females varied from 3.6 to 7.2 eggs per day and from 1.1 to 4.9 for the unmated females. The maximum number of eggs laid by a mated female was 505 and the minimum 139. Fertility of the mated females was high and the percentage of infertile eggs varied from 0.02% to 0.09% throughout the length of their mated lives. A minimum of two days was required before freshly emerged females produced any eggs. Only infertile eggs were produced four days following the death of the male. Unmated females seemed to be inhibited in egg laying, but upon mating, would deposit large numbers of eggs, up to 17, within 24 hours of copulation. In nearly all cases, all of these eggs were fertile.

Eggs were deposited primarily along the sides of the pans or jars containing the females. Floating pieces of cards, dead anopheline larvae, pieces of wood, bark, and dead and living leaves of various water plants were utilized. Of over 4,300 eggs, only 6 were deposited above the water surface, the remainder being placed just below the water surface, regardless of the medium upon which they were laid. Some eggs were air-dried for periods varying from 24 and one-half to 48 hours. In all cases, eggs less than three days old failed to develop, while a portion of those three days old did not. All of the eggs four, five, and six days old emerged but the embryonic period was extended to seven, eight, and nine days. Eggs only partially air-dried, and above a water surface, completed their development normally and in the usual time of six to seven days. Complete air-drying was fatal to the more immature eggs.

Observations on the number of acts of copulation of previously unmated adults revealed that five were made in a period of two and one-half hours and four each in two periods of one hour each. The acts lasted from one to six minutes, with a three-minute average.



Observations on the feeding of *Microvelia* adults in confined vials revealed that they fed in only two instances upon *Microvelia* eggs and in none upon the nymphs that emerged in the vials. In a large pan, with only six anopheline larvae present, the male did attack a first-stage nymph. It was concluded that when well fed, the adults do not feed regularly upon their own eggs and young. The adults were unable to pierce the integument of other adults with their mouth parts, so could not feed upon them. *Microvelia* did not feed upon anopheline eggs in a starvation test. The adults of *Microvelia* were able to find, attack, and feed upon anopheline larvae in an open pan, when only six larvae were present in an area of two-thirds of a square foot.

Wing development was correlated with the confined area of the vials. The specimens brought in from the field were about one-half alate and one-half apterous. This ratio was maintained in the broad breeding pans throughout the six months the experiment was conducted. In contrast, the second generation had only 27% alates, the third 3.7%, and the fourth 16%. Of the filial generations, the percentages of alates were 33%, 3.7%, and 16%. In the  $F_3$  generation, three alate males appeared as progeny of apterous parents, so aptery did not breed "pure." The possibility of the confined area being responsible for the increase in aptery is strongly suggested. Over-abundant food supply and the change of seasons are not considered as major factors, as the proportion of alate forms remained the same in the open breeding pans.

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## NEW SPECIES OF CRANE-FLIES FROM SOUTH AMERICA. PART XIII<sup>1</sup>

(Diptera: Tipulidae)

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The novelties discussed herewith are all from Peru and Ecuador, particularly from the former where they were collected in the Departments of Loreto and Huanuco, mostly by my friends Messrs. José M. Schunke and Felix Woytkowski. The types of the novelties are preserved in my large collection of these flies. All species fall in the great tribe Eriopterini, the Neotropical species of which have been listed by the writer in recent papers (Rev. de Entomologia, 17: 375-400, 1946; 18: 65-100, 1947; 18: 317-360, 1947).

### Genus *Trentepohlia* Bigot

#### *Trentepohlia* (*Paramongoma*) *tethys* sp. n.

General coloration dark brown; pleura and pleurotergite yellow; legs with the femora brown, the tips broadly white; tibiae black, the bases white, the tips more broadly so; basitarsi black, the outer third and remainder of tarsi white; wings subhyaline, stigma pale brown, triangular; extreme wing tip vaguely darkened; vein  $R_3$  oblique, in approximate longitudinal alignment with  $R_{2+3+4}$ .

*Female*.—Length, about 11 mm.; wing, 8.5 mm.

Rostrum yellow; basal two segments of palpi yellow, the outer two dark brown. Antennae with the scape and pedicel testaceous yellow, flagellum brownish black; flagellar segments elongate-oval to subcylindrical, verticils short. Front yellow; posterior part of head dark brownish gray; anterior vertex narrow, scarcely one-half the diameter of scape.

Pronotum brown. Mesonotum chiefly dark brown, the surface sparsely pruinose, more heavily so on the scutellum and mediotergite; humeral region of praescutum and central part of scutum obscure yellow; pleura and pleurotergite yellow, the mesepisternum a trifle more obscured. Halteres brownish black. Legs with the coxae and trochanters yellow, the fore coxae a trifle darker; femora brown, vaguely paler at bases, the tips broadly and abruptly snowy white; tibiae black, the bases similarly snowy white, a trifle more extensive than the femoral tips; tibial tips abruptly snowy white, a little more dilated, approximately twice the whitened bases; basitarsi black, the outer third or slightly more, as well as the remainder of tarsi, snowy white. Wings subhyaline; stigma pale brown, small, triangular in outline; extreme wing tip vaguely darkened; veins dark brown, *C*, *Sc* and *R* in the vicinity

<sup>1</sup>Contribution from the Entomological Laboratory, University of Massachusetts.

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of the stigma paler brown. Venation:  $Sc_2$  before the level of fork of  $R_s$ ;  $R_2$  about three times  $R_{3+4}$ ; vein  $R_3$  oblique, in approximate longitudinal alignment with  $R_{2+3+4}$ ;  $m-cu$  about two-fifths its length before the fork of  $M$ .

Abdominal tergites dark brown; sternites pale greenish yellow.

*Habitat*.—Peru (Huanuco). *Holotype*, ♀, Fundo Sinchono, altitude 1500 meters, August 4, 1947 (Schunke).

The most similar described species is *Trentepohlia* (*Paramongoma*) *metatarsata* Alexander, which differs in the coloration of the legs and in the venation.

### *Trentepohlia* (*Paramongoma*) *conscripta* sp. n.

General coloration brown, the praescutum somewhat darker medially; legs brown, the tarsi paling to yellow; wings with a pale brownish tinge, unpatterned except for the small brown stigma;  $R_{2+3+4}$  a trifle longer than  $R_{3+4}$ ; cell 1st  $M_2$  large, subequal to the distal section of vein  $M_3$ ; distance on margin between veins  $Cu_1$  and 1st  $A$  extensive, nearly equal to  $m-cu$ .

*Male*.—Length, about 6 mm.; wing, 7.3 mm.

Rostrum brown; palpi black. Antennae black throughout; flagellar segments oval, the verticils short. Head brown; anterior vertex very reduced.

Cervical region and pronotum brownish black. Mesonotum brown, the praescutum somewhat darker medially; pleurotergite and pleura somewhat more yellowish brown. Halteres infuscated. Legs with the coxae and trochanters brownish testaceous; remainder of legs brown, the tarsi paling to yellow. Wings with a pale brownish tinge, unpatterned except for the small oval brown stigma; prearcular and costal cells pale yellow; veins pale brown,  $Sc$  more yellowed. Venation:  $Sc_1$  ending about opposite  $R_2$ ;  $R_{2+3+4}$  a trifle longer than  $R_{3+4}$ ; cell 1st  $M_2$  large, subequal to the distal section of vein  $M_3$ ;  $m-cu$  shortly beyond the fork of  $M$ ; distance on margin between  $Cu_1$  and 1st  $A$  extensive, nearly equal to  $m-cu$ .

Abdominal tergites brown, the sternites and hypopygium more brownish yellow.

*Habitat*.—Peru (Huanuco). *Holotype*, ♂, Carpish, in dwarf fog forests, altitude 2800 meters, October 10, 1946 (Woytkowski). *Paratopotype*, ♂.

The most similar species is *Trentepohlia* (*Paramongoma*) *longifusa* Alexander, which is well distinguished by the small size and by details of coloration and venation.

### *Trentepohlia* (*Paramongoma*) *montivaga* sp. n.

Size relatively large (wing, male, 6.5 mm. or over); general coloration uniformly pale yellow, including the halteres and legs; wings pale yellow, with a restricted darkened seam over the distal section of vein  $Cu$ ; vein  $R_3$  oblique, only a little longer than  $R_{3+4}$ ; cell 1st  $M_2$  large, only a little shorter than the distal section of vein  $R_s$ .

*Male*.—Length, about 5–5.5 mm.; wing, 6.5–6.7 mm.

*Female*.—Length, about 6.5–7 mm.; wing, 7.5–8 mm.

Rostrum yellow, the reduced palpi infuscated. Antennae with the scape yellow, pedicel light brown, flagellum dark brown; flagellar segments oval, the verticils short and inconspicuous. Head buffy yellow; anterior vertex reduced to a linear strip.

Thorax uniformly yellow. Halteres uniformly pale. Legs yellow, the terminal tarsal segments weakly more darkened. Wings pale yellow, the prearcular and costal regions clearer yellow; a faintly indicated darkened seam on distal section of vein  $Cu_1$ ; veins yellow,  $Cu_1$  on its distal section especially more darkened. Venation:  $R_s$  arcuated; vein  $R_3$  oblique, only a little longer than  $R_{3+4}$ ; cell  $1st\ M_2$  large, only a trifle shorter than the distal section of vein  $R_5$ ; distal section of vein  $Cu_1$  variable in length, from subequal to fully twice  $m-cu$ .

Abdomen obscure brownish yellow; hypopygium, excepting the blackened dististyles, clearer yellow.

*Habitat*.—Peru (Huanuco). *Holotype*, ♂, Sariapampa, in fog forest, altitude 3600 meters, May 12, 1946 (Woytkowski). *Allotopotype*, ♀. *Paratopotypes*, several ♂♂ ♀♀.

Although very similar in its general appearance to *Trentepohlia* (*Paramongoma*) *cubitalis* Alexander, of southeastern Brazil, the present fly is obviously distinct, differing particularly in the large size and in the details of venation.

### Genus *Teucholabis* Osten Sacken

#### *Teucholabis* (*Paratropesa*) *nodulifera* sp. n.

Belongs to the *collaris* group. Pronotum light yellow, mesonotum purplish black; knobs of halteres light yellow; middle legs yellow; posterior femora yellow with two black rings; an unusually large dilation on more than the proximal half of the posterior basitarsus; wings pale yellow, conspicuously patterned with brown; basal dark band crossing both Anal cells to the margin, occupying half the extent of cell *2nd A*; abdomen black, the posterior borders of the sternites broadly yellow; mesal face of basistyle produced into a slender spine; outer dististyle terminating in a pale spine; aedeagus at apex with an abundance of strong setae, the apex a curved black spine.

*Male*.—Length, about 8 mm.; wing, 7.4 mm.

Rostrum yellow; palpi black. Antennae with the scape yellow below, more infuscated above; flagellum black; flagellar segments oval. Head above chiefly brownish black, the anterior vertex and posterior portion of the head more brownish yellow.

Prothorax uniformly pale yellow. Mesonotum polished black, the praescutum with vague purplish reflexions. Pleura black, the dorso-pleural region restrictedly pale; areas of gray bloom or pubescence above the middle and posterior coxae, apparently representing extensive silvery patches in fresh specimens. Halteres black, the knobs light yellow. Legs with the fore and middle coxae and trochanters light yellow, posterior coxae and trochanters black; fore legs broken; middle legs obscure yellow, the tarsi passing into brown; posterior femora yellow, with two black rings, one subbasal, the other subapical, the latter a little narrower and about one-half as extensive as the intervening yellow band; tibiae obscure yellow; tarsi obscure yellow, the basitarsi with more than

the proximal half dilated and blackened; outer tarsal segments brownish black; nodulose area on basitarsus, as described, larger and more conspicuous than in the other similar described species, being approximately three times as thick as the apical diameter of the segment. Wings pale yellow, conspicuously patterned with brown, as follows: A narrow band at cord, narrower and more intense at stigma, widened behind at the posterior border in cell 1st  $A$ ; wing tip more broadly infuscated, extending basad to the level of the outer end of cell 1st  $M_2$  and fork of  $R_{3+4}$ ; basad of cord, the darkenings restricted, very narrow at arculus, more expanded but paler in cells  $Cu$ , 1st  $A$  and 2nd  $A$ , occupying about one-half the extent of the last cell; veins brown, not or scarcely paler in the ground areas. Venation:  $R_2$  just basad of  $r-m$  producing a short element  $R_{3+4+5}$ ; vein  $R_3$  weakly sinuous, about one-third  $R_4$ ;  $R_5$  extensively fused with  $M_{1+2}$ , as in the group; cell 1st  $M_2$  narrow;  $m-cu$  at fork of  $M$ .

Abdomen black, the broad posterior borders of the sternites light yellow; subterminal segments and hypopygium black. Sternal pocket of segment five large and conspicuous, covering virtually the entire length of the segment, widened behind, the narrow cephalic end with a semilunate chitinized area; setae lateral, directed inward, the more caudal ones chiefly longer and more slender. Male hypopygium with the apical lobe of the basistyle slender, terminating in a short blackened point; mesal face of style, near base, with a strong erect black spine. Outer dististyle a small slender rod, its basal two-thirds more dilated, provided with about nine strong setae; outer third of style a straight pale spine. Inner dististyle large, complex in structure, the flattened beak black; basal arm with about a dozen strong setae. Aedeagus complex, dilated near apex and here provided with very numerous strong setae, the apex a curved black spine.

*Habitat*.—Peru (Huanuco). *Holotype*, ♂, Fundo Sinchono, altitude 1500 meters, August 4, 1947 (Schunke).

From the various other members of the *collaris* group, including *Teucholabis* (*Paratropesa*) *collaris* (Osten Sacken), the present fly differs in the diagnostic features listed, including the leg and wing pattern and structure of the legs and male hypopygium.

### ***Teucholabis* (*Teucholabis*) *ducalis* sp. n.**

Size large (wing, male, 8 mm. or more); general coloration black, the scutellum broadly light yellow; halteres with stem black, knob yellow; femora yellow, the tips broadly black; tarsi black; wings pale yellow, very heavily patterned with dark brown, including the narrow costal border, broad wing tip and narrow posterior margin; cord narrowly seamed with darker brown; male hypopygium with the spine of the basistyle stout-based; outer dististyle dilated on outer half, at near midlength with a strong spine.

*Male*.—Length, about 7–7.3 mm.; wing, 8–8.5 mm.

Rostrum short, approximately one-half the remainder of head, black throughout; palpi black. Antennae black throughout; basal five or six flagellar segments large, suboval, slightly produced apically on ventral face; outer segments oval; verticils shorter than the segments. Head dull black.

Pronotal scutum black, the scutellum and pretergites yellow. Mesonotum polished black, the scutellum broadly light yellow; a more restricted yellow median area at suture, involving parts of the prae-scutum and scutum. Pleura black, with a vague pruinose area on the posterior pleurites; dorsopleural region yellow. Halteres with stem black, knob yellow. Legs with all coxae and trochanters black; femora yellow, the tips broadly and conspicuously blackened, subequal in amount on all legs, including nearly the outer third on the fore and middle legs, the outer fifth on the more lengthened posterior femora; tibiae light to dark brown, the tips narrowly blackened; tarsi black; glandular area of posterior basitarsus only feebly dilated. Wings pale yellow, very heavily and conspicuously patterned with dark brown, including cells *C* and *Sc*; the broad wing tip, this continued around the posterior margin of wing as a narrow border; stigma, cord and outer end of cell *1st M*<sub>2</sub> narrowly darker brown; vague brown clouds or washes in the basal wing cells; veins brownish black. Venation: *Sc*<sub>1</sub> ending about opposite two-thirds the length of *Rs*; *R*<sub>2+3+4</sub> very short.

Abdomen, including hypopygium, black. Sternal pocket of segment five appearing as a long triangular area, narrowed in front, the inner vestiture consisting of relatively long black setae directed mesad; outer setae strong and powerful, likewise directed mesad. Male hypopygium with the spine of the basistyle near apex of mesal face, a stout-based rod that narrows at midlength into a strong black spine, at the point of narrowing with a dense brush of yellow setae; mesal flange not conspicuously crenulated or toothed. Outer dististyle a strong rod, the basal half a slender stem, the outer half more dilated or bulbous, the apex weakly bidentate; on mesal face at base of the expanded portion with a powerful spine, the opposite margin of style microscopically scabrous. Inner dististyle with the beak terminating in a cultriform blade, the usual lower spine replaced by a series of five or six weak serrations. Aedeagus terminating in a stout blackened subapical spine, the protruded axis with two pairs of setae, the more lateral ones stouter.

*Habitat*.—Peru (Huanuco). *Holotype*, ♂, Fundo Sinchono, altitude 1500 meters, August 6, 1947 (Schunke). *Paratopotypes*, 3 ♂♂, August 6–28, 1947 (Schunke).

This large and striking species is not closely related to others so far described. Superficially it suggests species such as *Teucholabis* (*Teucholabis*) *decora* Alexander, despite the body coloration, but all structures of the male hypopygium are distinct.

#### ***Teucholabis* (*Teucholabis*) *subanthracina* sp. n.**

Allied to *anthracina*. General coloration of body polished black; thoracic pleura with a broad longitudinal more silvery stripe; wings subhyaline, patterned with brown, including a narrow band at cord and the broader wing tip; *Sc*<sub>1</sub> ending about opposite two-thirds the length of *Rs*; male hypopygium with the outer dististyle long, terminating in two short spines, with a further slender spine on mesal edge at near midlength; inner dististyle with the beak produced into a single point, the lower or subapical one obsolete; lobe of style tipped with about six short stout spines of approximately equal size.

*Male*.—Length, about 6 mm.; wing, 4.9–5 mm.

Rostrum long and slender, subequal in length to the remainder of head, black, longer than in *anthracina*; palpi black. Antennae black throughout; flagellar segments oval, smaller and slightly more elongated outwardly, shorter than the verticils. Head black.

Thorax almost uniformly polished black, the pronotal scutellum and pretergites more reddened; mesonotal scutellum brownish black; dorsopleural membrane dark. Thoracic pleura with a broad longitudinal more silvery stripe extending from behind the fore coxae to the base of abdomen, passing beneath the root of the halteres. Halteres infuscated, knobs obscure yellow. Legs with all coxae black; trochanters dark brown; femora brownish black, the bases obscure yellow, involving approximately the basal half or less, the tips more blackened; tibiae brownish black; tarsi black; posterior basitarsi moderately dilated on proximal third. Wings subhyaline, patterned with pale brown, including a narrow band at cord and the broader apex, the latter not including the bases of cells 2nd  $M_2$  and  $M_3$ ; stigma oval, darker brown; cells basad of cord not or scarcely darkened. Venation:  $Sc_1$  ending about opposite two-thirds the length of  $Rs$ ,  $Sc_2$  just beyond one-fourth the length of  $Rs$ ; branches of  $Rs$  parallel for most of their lengths,  $R_5$  thence diverging strongly almost to the wing tip; *m-cu* from one-third to one-half its length beyond the fork of  $M$ .

Abdomen, including hypopygium, black. Sternal pocket of segment five placed near the posterior end of segment, long-oval, the center with microscopic setulae, the border with relatively few long strong bristles that are directed mesad; on sternite six with about a dozen strong setae in a longitudinal row on either side of the broad midline, the rows slightly more narrowed behind; an even weaker sternal area on segment seven, including five or six weak setae on either side of a median area. Male hypopygium with the spine of the basistyle on mesal face just beyond midlength, stout, extended at tip into a strong black spine; mesal margin with a row of long yellow setae; mesal flange blackened, conspicuous, the margin coarsely crenulate. Outer dististyle long, terminating in two short spines, with a long slender spine on mesal edge at near midlength; surface of style with numerous long coarse setae. Inner dististyle with the outer arm or beak produced into a single developed spine; lobe of style terminating in about six or seven short stout spines of approximately equal size. Aedeagus terminating in a strong blackened spine; surface of organ, at near midlength, with four long setae.

*Habitat*.—Ecuador (Santiago-Zamora). *Holotype*, ♂, Zumbi, Rio Zamora, altitude 700 meters, October 28, 1941 (Laddey). *Paratopotype*, ♂, October 31, 1941 (Laddey).

Although very similar in its general appearance to *Teucholabis* (*Teucholabis*) *anthracina* Alexander, the present fly seems to be quite distinct in the hypopygial characters, as above described. The type specimens had earlier (Rev. de Entomologia, 16: 374; 1945) been identified as *anthracina*.

***Teucholabis* (*Teucholabis*) *desdemona* sp. n.**

Size small (wing, male, about 4.5 mm.); general coloration polished black, variegated with yellow, including the scutellum; knobs of halteres

yellow; wings whitish, restrictedly patterned with brown, most conspicuous as the stigma and over the anterior cord;  $Sc$  short,  $Sc_1$  ending about opposite one-fourth the length of  $Rs$ , the branches of the latter strongly divergent; cell  $M_2$  normally open by the atrophy of the basal section of  $M_3$ ; abdominal segments bicolored, black and yellow; male hypopygium without an apical spine on basistyle; outer dististyle a long rod bearing a lateral spine at near two-thirds the length, terminating in a long straight spine; aedeagus with the apical point directed laterad.

*Male*.—Length, about 4–4.5 mm.; wing, 4–4.6 mm.

Rostrum short, black; palpi black. Antennae relatively long, if bent backward extending about to the root of wings; scape and pedicel obscure yellow, flagellum black; flagellar segments short-oval, strongly narrowed at outer ends, shorter than the verticils. Head polished black.

Prothorax and pretergites uniformly pale yellow. Mesonotum polished black, the scutellum and a central spot at suture yellow. Pleura chiefly occupied by a broad yellow longitudinal stripe extending from the prothorax across the dorsal sternopleurite, becoming more expanded on the meral and metapleural regions, the surface silvery pollinose; a large isolated black area on the ventral sternopleurite. Halteres brownish black, the knobs yellow. Legs with all coxae and trochanters yellow; fore femora black, the bases broadly yellow; tibiae yellowish brown, the tips blackened; tarsi black; middle and hind legs yellow, the tips of the femora and tibiae narrowly blackened; tarsi black; posterior basitarsi dilated on proximal third. Wings whitish, restrictedly patterned with brown, including cell  $Sc$ , stigma, a seam along the cord and a more or less distinct cloud at the outer medial fork; veins brown, those of the wing base more yellowed. Venation:  $Sc$  short,  $Sc_1$  ending about opposite one-fourth to one-fifth  $Rs$ ,  $Sc_2$  a short distance beyond this origin;  $R_2$  at or close to fork of  $Rs$ ; branches of  $Rs$  strongly divergent,  $R_5$  bent strongly caudad to the wing tip, cell  $R_4$  thus very wide, at least five times cell  $R_5$ ; cell  $M_2$  normally open by the atrophy of basal section of vein  $M_3$ , in one specimen, cell  $1st\ M_2$  closed; cell  $M_4$  distinctly narrowed at margin;  $m-cu$  close to fork of  $M$ .

Abdominal segments bicolored, black, the posterior borders of the intermediate segments broadly yellow; subterminal segments more uniformly yellow; hypopygium uniformly blackened. Sternal pocket of segment five broad, with abundant setae; of segment six with less numerous but stouter setae that are directed inward, arranged in two more or less parallel rows. Male hypopygium with the apex of basistyle obtuse, without a spine; mesal flange long and narrow, blackened, its margin weakly crenate. Outer dististyle a long rod, dilated on basal half and here with scattered setae and appressed spinulae, at near two-thirds the length with an appressed lateral spine, beyond which the style narrows into a long nearly straight spine. Inner dististyle without setae, the lower beak weakly bidentate. Aedeagus with the apical spine directed laterad, blunt at tip; surface of aedeagus with relatively numerous though not particularly strong setae.

*Habitat*.—Peru (Loreto). *Holotype*, ♂, Pucallpa, altitude 180 meters, March 22, 1947 (Schunke). *Paratopotypes*, 4 ♂♂, March 19–20, 1947 (Schunke).

From the other species of *Teucholabis* having no spine on the basi-



style of the male hypopygium, the present fly is readily told by the small size, coloration of the body and wings, and by the normally open cell  $M_2$ .

### Genus *Gnophomyia* Osten Sacken

#### *Gnophomyia* (*Eugnophomyia*) *flammeithorax* sp. n.

Allied to *tempestiva*. General coloration black, the thorax, including the pleura and sternum, uniformly bright orange, only the region of the metapleura blackened; antennae, halteres and legs black; wings with a strong blackish tinge; macrotrichia of cells beyond cord unusually numerous;  $R_2$  subequal to  $R_{2+3+4}$  and more than twice  $R_{3+4}$ .

*Female*.—Length, about 6.5 mm.; wing, 7.8 mm.; antenna, about 1.8 mm.

Rostrum and palpi black. Antennae black throughout; basal flagellar segments very short-cylindrical, the outer ones passing into oval; verticils subequal to or a trifle exceeding the segments. Head black.

Pronotum and propleura black. Mesonotum and pleura, with the sternum, uniformly bright orange, excepting only the meral and metapleural area above the hind legs. Halteres and legs uniformly black. Wings with a strong blackish tinge, the prearcular and costal fields slightly darker; stigma small, still darker brown; veins brownish black. Macrotrichia of cells beyond cord unusually numerous and conspicuous, lacking in the bases of the cells. Venation:  $Sc_1$  ending just before the level of the fork of  $Rs$ ,  $Sc_2$  close to its tip;  $R_2$  subequal to  $R_{2+3+4}$  and more than twice  $R_{3+4}$ ; *m-cu* about one-third its length beyond the fork of  $M$ .

Abdomen uniformly black. Ovipositor with the valves strongly developed, dark horn yellow.

*Habitat*.—Peru (Huanuco). *Holotype*, ♀, Carpish, in dwarf fog forests, altitude 2800 meters, October 2, 1946 (Woytkowski).

Among the various species of the subgenus having the thorax variously patterned with orange, the present fly is closest to species such as *Gnophomyia* (*Eugnophomyia*) *flagrans* Alexander and *G. (E.) tempestiva* Alexander, differing in the very extensive orange color of the thorax and in details of venation and trichiation of the wings.

#### *Gnophomyia* (*Gnophomyia*) *magniarcuata* sp. n.

Belongs to the *arcuata* group. Size very large (wing, female, 8 mm.); mesonotal praescutum almost uniformly plumbeous, pseudosutural foveae black; wings whitish subhyaline, stigma dark brown; vein  $Sc_1$  very long, approximately three-fourths as long as  $Rs$ ; *m-cu* about one-half its length before the fork of  $M$ .

*Female*.—Length, about 8 mm.; wing, 8 mm.

Rostrum gray pruinose; palpi black. Antennae black throughout; flagellar segments cylindrical, longer than the verticils. Head dark gray; anterior vertex broad, fully three times the diameter of scape.

Pronotum dark brownish gray; pretergites dark. Mesonotal praescutum almost uniformly dark gray or plumbeous; pseudosutural foveae black, extensive; posterior portion of scutal lobes, scutellum and

postnotum clear light gray, the mediotergite darker posteriorly. Pleura in front dark plumbeous gray, clear light gray behind, including the coxae. Halteres blackened. Legs with the coxae light gray; remainder of legs black. Wings whitish subhyaline; stigma dark brown; extreme wing base, including squama and the region of arculus, vaguely darkened; veins black. Venation: *Sc* long, *Sc*<sub>1</sub> ending just before the fork of *Rs*, *Sc*<sub>2</sub> far retracted so *Sc*<sub>1</sub> is very long, approximately three-fourths *Rs*; *R*<sub>2+3+4</sub> very strongly arcuated to subperpendicular at origin; *R*<sub>3+4</sub> shorter than *R*<sub>2</sub>; vein *R*<sub>4</sub> deflected strongly caudad on outer half, ending close to the wing tip; *m-cu* about one-half its length before the fork of *M*.

Abdomen elongate, black. Ovipositor with the cerci elongate, compressed-flattened; hypovalve much shorter, approximately one-third as long.

*Habitat*.—Peru (Huanuco). *Holotype*, ♀, Huamincha, forest zone, altitude 1600 meters, April 4, 1946 (Woytkowski).

The other described members of the group, including *Gnophomyia* (*Gnophomyia*) *arcuata* Alexander, *G. (G.) diazi* Alexander, and *G. (G.) subarcuata* Alexander, are all much smaller, with vein *Sc*<sub>1</sub> shorter.

#### *Gnophomyia* (*Gnophomyia*) *perdebilis* sp. n.

Belongs to the *tristissima* group. Allied to *maestilia*; general coloration black, the meral and metapleural region of thorax paling to yellow; antennae unusually long, approximately one-half the entire body; halteres black; wings with a strong blackish tinge, with somewhat darker washes over the anterior cord, in bases of cells *R* and *M* and along vein *Cu* in cell *M*; prearcular and costal fields more whitened; male hypopygium with the tergite conspicuous, its posterior margin with a row of scattered weak setae; mesal face of basistyle virtually unarmed; inner dististyle unusually long, approximately one-half as long as the simple outer style.

*Male*.—Length, about 5.5 mm.; wing, 6 mm.; antenna, about 2.7–2.8 mm.

*Female*.—Length, about 5.5 mm.; wing, 6 mm.

Rostrum and palpi black. Antennae (male) of unusual length for a member of the group, approximately one-half the length of body, black throughout; flagellar segments elongate-fusiform, narrowed at either end, subequal to the longest verticils. Head black, the front and anterior vertex more pruinose; anterior vertex broad, approximately four times the diameter of scape.

Pronotum and mesonotum black, the very restricted pretergites a trifle paler. Pleura dull black on dorsal portion, gray pruinose ventrally, the meral and metapleural regions paling to light yellow. Halteres uniformly black. Legs black. Wings with a strong blackish tinge, the elongate stigma darker brown; more dusky washes over the anterior cord, bases of cells *R* and *M*, and along vein *Cu* in cell *M*; prearcular and costal fields more whitened; a pale area near outer ends of cells *R* and *M* before cord; veins black. Venation: *Sc*<sub>1</sub> ending just beyond the fork of *R*<sub>2+3+4</sub>; *r-m* just before the fork of the nearly straight *Rs*; *m-cu* at or close to midlength of cell 1st *M*<sub>2</sub>.

Abdomen, including the genitalia, black throughout. Male hypopygium with the ninth tergite transverse, subrectangular, the caudal margin

with a row of scattered weak seta-like fimbriations, slightly more concentrated at the outer lateral portions; lateral fourth of tergal plate slightly more darkened, with scattered long coarse setae. Basistyle short and stout, the mesal face with about five strong slender setae but without further vestiture. Outer dististyle a stout flattened black blade, the apex obtuse. Inner dististyle unusually long, approximately one-half as long as the outer dististyle, apical portion strongly bent, the tip obtuse; distal half of style, especially the apex, with scattered strong setae, some much longer.

*Habitat*.—Peru (Huanuco). *Holotype*, ♂, Fundo Sinchono, altitude 1500 meters, August 1, 1947 (Schunke). *Allotopotype*, ♀, pinned with type. *Paratopotypes*, 7 ♂♂, January and August 1947 (Schunke).

The present fly is readily told from the most similar species, including *Gnophomyia* (*Gnophomyia*) *kertesiana* Alexander, *G. (G.) maestitia* Alexander, and *G. (G.) podacantha* Alexander, by the structure of the male hypopygium, especially the scarcely modified ninth tergite and the dististyles. The spines and fimbriations of the tergite in all of the now known numerous species appear to be direct extensions of the tergal plate rather than modified setae.

#### ***Gnophomyia* (*Gnophomyia*) *petentis* sp. n.**

Belongs to the *tristissima* group, allied to *maestitia*. Body and appendages black; antennae (male) unusually long, approximately one-half the length of the wing; wings with a strong blackish tinge; brown clouds over the anterior cord and along vein *Cu* in cell *M*; male hypopygium with the tergite large, the caudal margin nearly truncate, with a double row of strong spines, the lateral angles produced and tufted with longer spines; basistyle on mesal face at base bearing a strong blackened rod from an expanded ear-like base, with a further smaller spine on style near outer end; inner dististyle long-oval, terminating in a blackened spinous point; aedeagus long and slender.

*Male*.—Length, about 5–5.5 mm.; wing, 5–6 mm.; antenna, about 2.5–2.7 mm.

*Female*.—Length, about 6.5 mm.; wing, 5.5 mm.

Entire body, with the palpi, antennae, halteres and legs, black; anterior pretergites with a small yellow area. Antennae unusually long, as shown by the measurements; flagellar segments elongate-subcylindrical or slightly dilated at midlength, a little shorter than the verticils. Wings with a strong blackish tinge, the stigma elongate, still darker; brown clouds, intermediate in color, over the anterior cord and along vein *Cu* in cell *M*; veins brownish black. Venation: *Rs* nearly straight; basal section of *R*<sub>5</sub> lacking or virtually so, *Rs* in alignment with *R*<sub>5</sub>; *m-cu* at near midlength of cell 1st *M*<sub>2</sub>.

Male hypopygium with the tergite large, the caudal margin nearly truncate, with a double row of strong spines, totalling about 80 to 90; lateral ends of tergal plate produced, bearing about a dozen longer black spines. Basistyle on mesal face of proximal end bearing a very strong blackened rod with a flattened ear-like base; near outer end of style on mesal face with a further smaller strong spine. Outer dististyle a simple gently curved rod, the tip obtuse. Inner dististyle small, long-oval, terminating in a blackened spinous point; surface with several

setae, the longest subequal in length to the style itself. Aedeagus long and slender.

*Habitat*.—Peru (Huanuco). *Holotype*, ♂, Fundo Sinchono, altitude 1600 meters, August 25, 1947 (Schunke). *Allotopotype*, ♀. *Paratopotype*, ♂, August 2, 1947 (Schunke).

The most similar described species include *Gnophomyia* (*Gnophomyia*) *kerteszi* Alexander, G. (G.) *podacantha* Alexander, G. (G.) *permagica* Alexander, and G. (G.) *tungurahua* Alexander, all of which differ conspicuously among themselves and from the present fly in the structure of the male hypopygium.

### *Gnophomyia* (*Gnophomyia*) *trisetigera* sp. n.

General coloration black, including also the antennae, halteres and legs; antennae (male) relatively long, nearly one-half the body; pleura with a broad silvery longitudinal stripe on the dorsal sternopleurite, paling to yellow on the meral region; halteres brownish black; wings with a strong brownish tinge, vaguely patterned with still darker brown; *r-m* at fork of *Rs*; *R*<sub>2</sub> nearly obsolete, transverse; male hypopygium with the tergite large, conspicuously emarginate by a V-shaped notch, the margins of the lobes without spines or modified setae; basistyle on mesal face of cephalic end with a strong dusky lobe that bears three strong setae; inner dististyle bilobed on outer half, both lobes bearing relatively few setae.

*Male*.—Length, about 5.5 mm.; wing, 5.8 mm.; antenna, about 2.5 mm.

Rostrum and palpi black. Antennae (male) relatively long, nearly one-half the body, black throughout; flagellar segments elongate-subcylindrical, the longest verticils subequal to or slightly longer than the segments. Head dull black; anterior vertex very broad, nearly four times the diameter of the scape; a low tubercle on anterior vertex.

Pronotum brownish black; anterior pretergites and lateral ends of the pronotal scutellum yellow. Mesonotum black, the scutellum and mediotergite slightly pruinose. Pleura black, with a broad silvery longitudinal stripe on the dorsal sternopleurite, paling to yellow on the ventral pteropleurite and meral region; dorsopleural membrane infuscated. Halteres brownish black. Legs with the fore coxae brownish black, the middle and posterior pairs paler; trochanters brown; remainder of legs black. Wings with a strong brownish tinge, even deeper in color over the anterior cord and in cell *M* adjoining vein *Cu*; stigma elongate, darker brown; veins brownish black. Venation: *Sc*<sub>1</sub> ending nearly opposite the fork of *R*<sub>2+3+4</sub>, *Sc*<sub>2</sub> some distance from its tip; *r-m* at fork of *Rs*; vein *R*<sub>2</sub> nearly obsolete, transverse; cell 1st *M*<sub>2</sub> long, with *m-cu* just before midlength. The right wing of the holotype has an adventitious crossvein near the base of cell 2nd *M*<sub>2</sub>.

Abdomen black. Male hypopygium with the ninth tergite large, conspicuously emarginate by a V-shaped notch, the margins of the broad lobes thus formed smooth; dorsum of each lobe with about a dozen strong setae. Basistyle short and stout, near base of mesal face with a strong dusky tubercle bearing three strong setae. Outer dististyle a simple slender glabrous rod, its tip obtuse. Inner dististyle bilobed on outer half, the outer arm or lobe longest, both lobes bearing few setae. Apex of phallosome emarginate.

*Habitat*.—Peru (Huanuco). *Holotype*, ♂, Fundo Sinchono, altitude 1500 meters, August 2, 1947 (Schunke). *Allotopotype*, ♀, pinned with type.

While generally similar in appearance to species such as *Gnophomyia* (*Gnophomyia*) *maestitia* Alexander and related species, the present fly is entirely distinct in the structure of the male hypopygium, particularly the tergite, basistyle and inner dististyle.

### *Gnophomyia* (*Gnophomyia*) *socialis* sp. n.

General coloration of praescutum brownish gray, paling to reddish brown on sides; thoracic pleura striped with brownish black; halteres yellow, knob dark brown; femora yellow, the tips narrowly dark brown; wings yellow, restrictedly patterned with brown, best indicated by a darkening of the cord and outer end of cell *1st M*<sub>2</sub>; vein *R*<sub>2</sub> close to the fork of *R*<sub>2+3+4</sub>, about one-third *R*<sub>1+2</sub>; cell *1st M*<sub>2</sub> long and narrow; male hypopygium with the inner dististyle bilobed, both lobes blackened.

*Male*.—Length, about 6 mm.; wing, 6.5 mm.

Rostrum yellow; palpi brown. Antennae with scape and pedicel obscure testaceous yellow, flagellum black, the first segment paler; flagellar segments oval, slightly shorter than their verticils. Head yellow.

Pronotum yellow above, brown on the sides; pretergites whitened. Mesonotal praescutum brownish gray medially, paling to reddish brown on sides, humeral region and lateral border pale yellow; posterior sclerites of notum dark brown; posterior angles of scutal lobes obscure yellow; posterior border of scutellum yellow. Pleura and pleurotergite yellow, with a broad conspicuous brownish black longitudinal stripe extending from the cervical region across the dorsal pleurites, merging gradually with the yellow ground of the ventral edge; dorsopleural membrane abruptly yellow. Halteres with stem light yellow, knob dark brown. Legs with coxae and trochanters pale yellow; femora yellow, the tips narrowly dark brown; remainder of legs yellow, the outer tarsal segments infuscated. Wings with the ground yellow, the prearcular and costal fields even clearer yellow; a restricted brown pattern, including the stigma, cord and outer end of cell *1st M*<sub>2</sub>, the latter two best-indicated by the darkened veins; very pale brown washes near outer end of cell *M* and across bases of cells *Cu* and *2nd A*; veins yellow, those beyond cord somewhat darker. Venation: *Sc*<sub>1</sub> ending a short distance before the level of vein *R*<sub>2</sub>; *r-m* shortly before the fork of *Rs*; *R*<sub>2</sub> at or close to fork of *R*<sub>2+3+4</sub>, about one-third *R*<sub>1+2</sub>; veins *R*<sub>3</sub> and *R*<sub>4</sub> long, generally parallel to one another for their entire lengths; cell *1st M*<sub>2</sub> long and narrow, gently widened outwardly; *m-cu* at near midlength of *M*<sub>3+4</sub>.

Abdominal tergites brownish black, the lateral borders narrowly pale. Male hypopygium with the basistyle short and stout, unarmed. Outer dististyle a simple blackened rod, the tip obtuse, the mesal face at near midlength microscopically scabrous. Inner dististyle unusually compact, unequally bilobed, the outer lobe a blackened knob, the tip obtuse, the inner lobe smaller, likewise blackened; surface of style above with a transverse row of five strong bristles. Phallosome depressed-flattened, terminating in a central blackened knob, its tip obtuse.

*Habitat*.—Peru (Huanuco). *Holotype*, ♂, Chinchao, altitude 2500 meters, in wooded hills, September 20, 1947 (George Woytkowski).

Among the other regional species that have the wings slightly patterned with darker, including *Gnophomyia* (*Gnophomyia*) *argutula* Alexander, *G. (G.) duplex* Alexander, and *G. (G.) regnatrix* Alexander, the present fly is most similar to the last in general coloration and wing pattern. It differs conspicuously in the small size and in the details of venation. The male sex of *regnatrix* is still unknown.

***Gnophomyia* (*Gnophomyia*) *subflebilis* sp. n.**

*Male*.—Length, about 5 mm.; wing, 5.5 mm.; antenna, about 1.1 mm.

Characters generally as in *flebilis* Alexander, differing in important hypopygial characters. Wings with the base not so scarcely brightened; stigma present but very narrow. Male hypopygium having the ninth tergite with its caudal margin very gently convex, on either side of the midline and widely separated with a stout darkened tubercle. Outer dististyle unusually long and slender, narrowed very gradually to the acute tip. Inner dististyle with the basal lobe low, provided with two strong setae, the remainder of upper face of style with nine further similar setae; ventral surface of apex with a further group of short spinous setae. Phallosome relatively narrow, the apex blackened, obtuse.

*Habitat*.—Ecuador (Santiago-Zamora). *Holotype*, ♂, Zumbi, Rio Zamora, altitude 700 meters, November 1, 1941 (Laddey).

The present fly is close to *Gnophomyia* (*Gnophomyia*) *flebilis* Alexander and *G. (G.) peracutior* sp. n., the chief distinctions being found in the structure of the male hypopygium. Both *peracutior* and *subflebilis* have the knobs of the halteres deep yellow.

***Gnophomyia* (*Gnophomyia*) *peracutior* sp. n.**

General coloration black, the posterior pleurites faintly pruinose; halteres with stem blackened, knob deep yellow; femora brownish black; wings with a strong brownish tinge, more yellowed at base; no stigmal darkening;  $R_{1+2}$  relatively long, exceeding one-half  $R_s$ ; male hypopygium with inconspicuous lateral tergal tubercles; outer dististyle gradually narrowed into a long acute spine.

*Male*.—Length, about 5.5 mm.; wing, 6 mm.; antenna, about 1.4 mm.

Rostrum and palpi black. Antennae black throughout; flagellar segments oval. Head black.

Thorax almost uniformly black, the surface subnitidous; pretergites narrowly obscure yellow; posterior pleurites faintly pruinose, more heavily so on the metapleural region; meron paler. Halteres with stem blackened, knob deep yellow. Legs with the coxae brownish black; trochanters brownish yellow; femora brownish black, the bases narrowly more yellowed, most evidently so on the posterior pair; tibiae and tarsi brownish black to black. Wings with a strong brownish tinge, the prearcular field narrowly but conspicuously yellow; no evidence of a stigmal darkening; veins brown, pale in the brightened basal portions. Venation:  $R_s$  gently arcuated, not as extended basally as in *subflebilis*;  $R_{1+2}$  longer than in the latter species, exceeding one-half the length of  $R_s$ ; cells beyond cord longer than in *subflebilis*.

Abdomen, including hypopygium, brownish black. Male hypopygium with the outer lateral angles of the tergite terminating in a small inconspicuous tubercle; from beneath the tergite juts caudad what is presumed to be the proctiger, each outer lateral angle of which bears a single strong seta. Outer dististyle long and slender, gradually narrowed into a long acute spine, this apparently more slender than in *subflebilis*. Inner dististyle stout, with about four strong setae on the low basal lobe and six others more distad. Phallosome terminating in a relatively narrow blackened knob.

*Habitat*.—Peru (Huanuco). *Holotype*, ♂, Fundo Sinchono, altitude 1500 meters, August 5, 1947 (Schunke).

This fly is most nearly allied to *Gnophomyia* (*Gnophomyia*) *subflebilis* sp. n., differing especially in the coloration of the body and wings and in the details of venation and structure of the male hypopygium.

### *Gnophomyia* (*Gnophomyia*) *tricornis* sp. n.

General coloration of the body black, the mesonotum subnitidous; anterior pretergites restrictedly yellow; metapleural region and knobs of halteres abruptly yellow; wings whitish subhyaline, stigma large, pale brown, inconspicuous; *r-m* at or before the fork of *Rs*; *R*<sub>2</sub> very faint to virtually obsolete; cell 1st *M*<sub>2</sub> elongate; male hypopygium with the outer dististyle a strong glabrous rod, narrowed to the obtuse more yellowed apex; inner dististyle with two arms, the basal lobe being unusually long, approximately two-thirds the main axis of the style.

*Male*.—Length, about 5.2–5.3 mm.; wing, 6 mm.; antenna, about 1.3–1.4 mm.

Rostrum and palpi black. Antennae black throughout; flagellar segments oval to long-oval. Head dull black, sparsely pruinose.

Pronotum black, the anterior pretergites restrictedly yellow. Mesonotum uniformly black, the surface subnitidous. Pleura black, sparsely pruinose to produce a somewhat plumbeous appearance; metapleural region abruptly yellow; dorsopleural membrane black. Halteres with stem black, knob conspicuously light yellow. Legs uniformly black. Wings whitish subhyaline or with a very weak brownish tinge; stigma large, pale brown, inconspicuous; veins dark brown, *Sc* more yellowed. Venation: *Sc*<sub>1</sub> ending from about opposite the fork of *Rs* to near mid-length of *R*<sub>2+3+4</sub>, *Sc*<sub>2</sub> some distance from its tip; *r-m* at or shortly before the fork of *Rs*; *R*<sub>2</sub> transverse, very faint to virtually obsolete; cell 1st *M*<sub>2</sub> long, subequal to vein *M*<sub>3</sub> beyond it; *m-cu* at near one-third to one-fourth the length of cell 1st *M*<sub>2</sub>.

Abdomen, including hypopygium, black throughout. Male hypopygium distinctive. Tergal region not well developed nor spinous. Basistyle simple, unarmed, the inner apical portion with a group of very long yellow setae from hyaline punctures; outer face of style with the setae small and scattered. Outer dististyle a strong simple glabrous rod, narrowed to the obtuse yellow apex, on mesal face before apex microscopically serrulate, including an outer stronger apiculate point. Inner dististyle a long straight arm, at apex bent upward into a lobe that is provided with strong setae; at base of this arm with a strong branch that is approximately two-thirds as long, from a dilated base, the surface of outer face and apex with strong scattered setae. Phall-

osome a blackened mass, the apex narrowed into an obtuse, more strongly darkened part.

*Habitat*.—Peru (Huanuco). *Holotype*, ♂, Sariapampa, in fog forest, altitude 3600 meters, May 4, 1946 (Woytkowski). *Paratopotype*, 1 ♂, May 11, 1946 (Woytkowski).

Superficially the present fly resembles species such as *Gnophomyia* (*Gnophomyia*) *maestilia* Alexander and relatives but is entirely distinct from all other black species having the knobs of the halteres yellow. The structure of the inner dististyle of the male hypopygium is distinctive.

### ***Gnophomyia* (*Gnophomyia*) *adjusta* sp. n.**

General coloration black, the mesonotum subopaque by a weak bloom; antennae and legs black; halteres black, the knobs conspicuously bright yellow; wings with a strong brownish tinge, stigma not indicated; *Sc* short, *Sc*<sub>1</sub> ending about opposite the fork of *Rs*; cell 1st *M*<sub>2</sub> long and narrow, subequal to vein *M*<sub>4</sub>; male hypopygium with the median region of the caudal border produced into pale membranous tissue; outer dististyle blackened, twisted before the more yellowed obtuse apex; inner dististyle with unusually numerous setae.

*Male*.—Length, about 6.5 mm.; wing, 5.8 mm.; antenna about 1.5 mm.

Rostrum and palpi black. Antennae black throughout, the scape more pruinose; flagellar segments oval, the outer ones progressively shorter; verticils much longer than the segments. Head dull black; anterior vertex broad, the eyes relatively small.

Pronotum brownish black, the lateral ends and the anterior pretergites obscure orange yellow; an even more restricted brightening on the posterior pretergites before the wing root. Mesonotum black, the surface subopaque by a weak bloom. Pleura black, more pruinose ventrally, especially behind; meral region vaguely brightened. Halteres black, the knobs conspicuously bright yellow. Legs with the coxae black, more or less pruinose, the middle pair heavily so; remainder of legs black. Wings with a strong brownish tinge; stigma not indicated; veins dark brown. Venation: *Sc* short, *Sc*<sub>1</sub> ending about opposite the fork, *Sc*<sub>2</sub> about opposite two-thirds the length of *Rs*; *Rs* oblique, nearly straight, *r-m* close to its fork; vein *R*<sub>2</sub> faint, slightly oblique, at or beyond the fork of *R*<sub>2+3+4</sub>; cell 1st *M*<sub>2</sub> long and narrow, slightly widened outwardly, subequal in length to vein *M*<sub>4</sub>; *m-cu* just before midlength of cell 1st *M*<sub>2</sub>.

Abdomen, including hypopygium, black. Male hypopygium with the tergite transverse, relatively long, the median region of the caudal border further produced into paler membranous tissue, as is common in a section of the subgenus; this is distorted and torn in the type and cannot be accurately described. Basistyle stout, blackened, without lobes. Outer dististyle a glabrous blackened rod, gently curved, twisted before the obtuse more yellowed apex. Inner dististyle with the apical portion a cylindrical tumid lobe, its tip obtuse; basal part lower and slightly more pointed, the margin of the notch microscopically roughened; surface of entire style with unusually numerous setae. Phallosome blackened, nearly cordate in outline, the obtuse apex more blackened.



*Habitat*.—Peru (Huanuco). *Holotype*, ♂, Sariapampa, in fog forest, altitude 3600 meters, May 8, 1946 (Woytkowski).

In its blackened body and legs, the present fly is superficially like various members of the *tristissima* group, such as *maestitia* Alexander, having the ninth tergite of the male hypopygium variously armed with spinous setae. From the structure of the male hypopygium, it is evident that it is closer to species such as *Gnophomyia* (*Gnophomyia*) *fessa* Alexander, *G. (G.) justa* Alexander, *G. (G.) lata* Alexander, *G. (G.) porteri* Alexander, and others, differing in the details of structure of the hypopygium, in the venation, and in the uniformly blackened legs.

***Gnophomyia* (*Gnophomyia*) *pauciseta* sp. n.**

General coloration of thorax black, sparsely pruinose; knobs of halteres yellow; legs brownish black; wings with a weak brownish tinge; vein  $R_2$  slightly oblique; male hypopygium with the tergite long, with numerous setae; mesal face of basistyle produced into a large obtuse lobe; outer lobe of inner dististyle with unusually few setae, these restricted to the outer third; phallosome broadly oval, the apex blackened, entire.

*Male*.—Length, about 7.5 mm.; wing, 7.5 mm.; antenna, about 1.6 mm.

Rostrum and palpi black. Antennae black throughout, of moderate length; flagellar segments subcylindrical, a little shorter than the verticils. Head dull black; eyes very large, the anterior vertex correspondingly reduced.

General coloration of thorax black, the surface opaque by a sparse pruinosity, the anterior pretergites restrictedly more brightened; humeral region of praescutum light gray pruinose, enclosing the black pseudo-sutural foveae; posterior borders of scutal lobes obscure yellow. Pleura somewhat paler across the dorsal sternopleurite, becoming pruinose behind, the metapleura yellow. Halteres infuscated, the knobs conspicuously yellow. Legs with the coxae dark brown; trochanters yellowish brown, the hind pair clearer yellow; remainder of legs dark brown to brownish black, the tibiae a trifle paler than the femora. Wings with a weak brownish tinge, the restricted prearcular field more yellowed; stigma long and very narrow, slightly darker brown, inconspicuous; veins brown, yellow in the prearcular field. Venation:  $Sc_1$  ending immediately before the cephalic end of the slightly oblique  $R_2$ ;  $r-m$  close to the fork of  $R_s$ ; cell 1st  $M_2$  subequal in length to vein  $M_4$ , with  $m-cu$  just beyond one-fourth the length.

Abdomen, including hypopygium, black. Male hypopygium with the tergite relatively long, the length approximately one-third the transverse diameter or width; surface with relatively numerous setae, the lateral ones long and stout; median region of tergite produced into a broad flattened lobe, the apex rounded and membranous. Basistyle stout, its mesal face produced into a large obtuse lobe provided with setae. Outer dististyle a simple glabrous rod, the outer half more narrowed, gradually produced to the subacute tip; the style of one side only bears a single strong seta on outer face before apex. Inner dististyle with the outer lobe long, clavate, with unusually few setae, these restricted approximately to the outer third; the enlarged basal

part of style with relatively few setae. Phallosome broadly oval, the apex blackened, entire; aedeagus jutting beyond the apex of the major phallosomic structure as a slender rod, its apex capitate, yellow.

*Habitat*.—Peru (Huanuco). *Holotype*, ♂, Fundo Sinchono, altitude 1500 meters, August 5, 1947. (Schunke).

The present fly is most similar to species such as *Gnophomyia* (*Gnophomyia*) *flebilis* Alexander, *G. (G.) lata* Alexander, *G. (G.) perlata* Alexander, and others, differing especially in the structure of the male hypopygium.

### *Gnophomyia* (*Gnophomyia*) *persevera* sp. n.

Mesonotum almost uniformly dark brown; antennae short; pleura with a brown dorsal stripe; halteres infuscated; wings with a weak brown tinge; veins delicate;  $Sc_1$  ending shortly before the slightly oblique  $R_2$ ; cell 1st  $M_2$  long and narrow, with *m-cu* at one-third its length; male hypopygium brownish black; tergite unusually narrow, unmodified, provided with sparse setae; no lobes on basistyle; phallosome oval, the apex narrowly emarginate.

*Male*.—Length, about 5.5 mm.; wing, 5.2 mm.; antenna, about 1.2 mm.

*Female*.—Length, about 6 mm.; wing, 6.5 mm.

Rostrum and palpi brownish black. Antennae relatively short, brownish black throughout; flagellar segments subcylindrical, the longest verticils exceeding the segments. Head dark gray, lighter gray on front and anterior vertex, the latter (in male) narrow, about one-half wider than the diameter of the scape, the eyes correspondingly large.

Pronotum orange-yellow above, darker on sides; pretergites paler yellow. Mesonotum almost uniformly dark brown, the praescutum more pruinose; lateral borders of scutal lobes obscure yellow, parascutella brown; pleurotergite dark brown on ventral portion, paling to yellow on dorsal half in male, uniformly darkened in female. Pleura with a broad dark brown longitudinal stripe, the ventral sclerites abruptly brownish yellow, clearer yellow behind; dorsopleural region narrowly yellow. Halteres infuscated, the base of stem narrowly yellow. Legs with the coxae yellow, the fore pair darker, the posterior coxae clear light yellow; trochanters yellow; femora obscure yellow, the tips more infuscated; tibiae and tarsi light brown, the outer tarsal segments passing into brownish black. Wings with a weak brownish tinge, the prearcular field more yellowed; stigma elongate, pale brown, only a little darker than the ground; veins very delicate, brown, more yellowed in the prearcular field. Venation:  $Sc$  long,  $Sc_1$  ending shortly before the level of the cephalic end of the oblique semiobliterated  $R_2$ ;  $R_s$  straight, *r-m* at its fork; cell 1st  $M_2$  long and narrow, subequal to or a trifle shorter than vein  $M_4$ , with *m-cu* at one-third its length.

Abdomen, including hypopygium, brownish black. Male hypopygium with the tergite unusually narrow, the transverse width fully five times the longitudinal dimension; caudal margin unarmed and not produced medially behind, as in related species; setae sparse and delicate, arranged virtually in a single row, this becoming double on the central third of the sclerite. Basistyle without lobes. Outer dististyle a glabrous darkened rod, narrowed gradually to the subacute tip. Inner

dististyle with the apical lobe nearly parallel-sided, at apex produced ventrad into a lobe; basal lobe moderately developed. Phallosome oval in outline, the apex narrowly emarginate, each lobe thus formed blackened at apex.

*Habitat*.—Peru (Loreto). *Holotype*, ♂, Cerro Azul, April 30, 1947 (Schunke).

Most nearly allied to species such as *Gnophomyia* (*Gnophomyia*) *banksiana* Alexander, *G. (G.) subhyalina* Alexander, and *G. (G.) vilis* Alexander, differing from all in the structure of the male hypopygium. The very narrow ninth tergite is noteworthy.

***Gnophomyia* (*Gnophomyia*) *mediotuberculata* sp. n.**

Mesonotum chiefly brown, the humeral region of praescutum yellow; pleura yellow with a broad conspicuous brownish black longitudinal stripe across the dorsal sclerites; knobs of halteres brownish black; wings with a weak grayish tinge; stigma brownish yellow, small and scarcely evident; vein  $R_2$  distinct, transverse; cell 1st  $M_2$  small, *m-cu* at near midlength; male hypopygium with the tergite transverse, its posterior portion extended into a long depressed-flattened lobe; on surface of tergite with a tubercle bearing several strong setae; outer dististyle flattened and twisted; inner dististyle produced laterad at tip into a short point; phallosome emarginate medially, the two lateral lobes thus formed blackened and microscopically roughened.

*Male*.—Length, about 8 mm.; wing, 6.5 mm.; antenna, about 1.8 mm.

*Female*.—Length, about 8 mm.; wing, 7 mm.

Rostrum and palpi black. Antennae with the scape brown, pedicel testaceous yellow, flagellum dark brown; flagellar segments long-subcylindrical, the longest verticils exceeding the segments. Head brownish gray, the orbits clearer gray; eyes large, the anterior vertex (male) relatively narrow, apparently less than three times the diameter of the scape.

Mesonotum chiefly brown, the humeral and lateral portions of praescutum yellow, pseudosutural foveae blackened; posterior lateral portions of scutal lobes and the narrow posterior border of the scutellum obscure yellow; anterolateral parts of mediotergite yellowed. Pleura yellow, with a broad conspicuous brownish black longitudinal stripe extending onto the pteropleurite. Halteres short, brownish black, the basal half of stem yellow. Legs with the coxae and trochanters yellow; femora and tibiae yellow, the tips more infuscated; tarsi brown, the basitarsi paler. Wings with a weak grayish tinge; stigma small and scarcely indicated, brownish yellow, not crossing vein  $R_{1+2}$  behind; veins brown, more brightened in the stigmal and prearcular fields. Venation:  $Sc_1$  ending opposite  $R_2$ ,  $Sc_2$  just beyond the level of the fork of  $R_s$ ; *r-m* at fork of  $R_s$ ; vein  $R_2$  distinct, transverse; cell 1st  $M_2$  relatively small, shorter than any of the veins beyond it, the second section of vein  $M_{1+2}$  less than one-third the outer section in male, somewhat longer in female; *m-cu* at near midlength of cell 1st  $M_2$ ; cell 2nd  $A$  broad, the vein gently arcuated.

Abdominal tergites brownish black, sternites yellow; hypopygium, including tergite and basistyle, yellow, the dististyles darkened. Male hypopygium with the tergite transverse, the posterior portion produced

caudad into a long depressed-flattened extension, the rounded apex with microscopic setulae; on surface at midline of tergite with a rounded tubercle bearing about ten strong setae. Basistyle stout, the mesal face at near midlength produced into a pale fingerlike lobe. Outer dististyle a flattened twisted rod, the mesal margin near base microscopically toothed or roughened. Inner dististyle about two-thirds as long, at apex produced laterad into a blunt point. Phallosome with the lobe of either side blackened, the surface microscopically roughened; tip of aedeagus jutting caudad beyond the central emargination.

*Habitat*.—Peru (Loreto). *Holotype*, ♂, Contamana, Upper Ucayali River, May 22, 1947 (Schunke). *Allotopotype*, ♀, pinned with type.

Most like species such as *Gnophomyia* (*Gnophomyia*) *apicularis* Alexander, *G. (G.) subapicularis* Alexander, and allies, differing most evidently in the structure of the male hypopygium, especially the tergite, dististyles, and phallosome.

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ANNALES UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA.—This publication of The University Maria Curie-Skłodowska, Lublin, Poland, is divided into six sections, of which Section C is devoted to the Biological Sciences. The plan, according to the statement of the editors, is to publish 240 to 400 printed pages in each section of each annual volume, and to take care of longer articles in supplements. Section C, Volume I (1946-1947), contains 9 numbers, Volume II (1947), 13 numbers, and Volume III (1948), apparently 14 numbers. There have been three supplements, all dated 1947. The following papers deal with arthropods: N. Nicewicz, W. Nicewicz, and R. Kowalik, "Description of micro-organisms supported on the bacteriological analysis in the alimentary tracts of the bed bug, house fly and cockroach," Vol. I, No. 2; Jarosław Urbański, "Les Isopodes du district de Poznań," Vol. I, No. 3; Konstanty Strawiński, "Contribution to the biology and occurrence of *Neurotoma nemoralis* L. (*Hymenoptera-Pamphiliidae*) in Poland," Vol. II, No. 4; Urbański, "Contributions à la connaissance des zoocedidies des environs de Gdynia," Vol. II, No. 6; Urbański, "*Aeschna subarctica* Walker (Odonata Aeschnidae) dans le district Kartuzy," Vol. II, No. 10; Urbański, "Notes odonatologiques de la Bulgarie," Vol. II, No. 11; Hieronim Jawłowski, "Studies on the insects brain," Vol. III, No. 1; Urbański, "Critical review of dragon-flies (Odonata) of Poland," Vol. III, No. 11; and Stanisław Jakubisiak, "Ants in the environments of Przybyszewo (South Masovia), ecological study," Vol. III, No. 12. Supplement III is a "History of Zoology in Poland till 1918, parts I and II," by Gabriel Brzek.

An occasional article is in English (notably Jawłowski's "Study of the insect brain") or French; most are in Polish, with an English or French summary which may range from one that is dismayingly brief to one that almost amounts to a translation. The paper is of reasonably good quality; the print and the reproduction of drawings, color plates, and photographs are quite satisfactory. The articles seem to represent, at least for the most part, substantial contributions to science. The loss caused by destruction and dissipation of energy resulting from the war is evident as one looks through the articles, and one must admire the courage of a people who have produced work of this quality under such unfavorable circumstances. An example of this is to be found in the studies of ants by Jakubisiak, which the author carried on as a displaced person during the war years.—M. T. J.

## BOOK NOTICE

BIOCHEMICAL EVOLUTION, by MARCEL FLORKIN. Edited, translated, and augmented by Sergius Morgulis. vii+157 pp., 24 fig. The Academic Press, New York. 1949. Price, \$4.00.

During the past few decades there has developed among systematic zoologists and students of evolution, a growing realization that the concept of the species and its genetic relation to other species must be biological rather than primarily morphological in philosophy, and that morphologic differences and similarities among and between species usually have true validity only when they reflect, or are associated with, more profound biological differences and similarities. By extension, then, our concepts of evolution, as conceived primarily from the classical morphologic criteria, must be tested from the aspect of the progression of biological changes in general rather than simply on the basis of the progression of morphologic changes. The most fundamental of the biological changes are those which may be designated as biochemical. *Biochemical Evolution* is a refreshing, condensed inventory and analysis of biochemical facts and philosophy as they relate to evolution and phylogeny. The status of the biochemical approach to the study of evolution and phylogeny is well described by the author: "The study of biochemical characteristics depends upon techniques which frequently are complicated, and such a study is more difficult to accomplish than direct observation of morphological characters. Nevertheless, had naturalists started from these rather from morphological observations, they would have been bound to conceive the idea of evolution of animals. They could not have failed to recognize the phenomena of orthogenesis and adaptation, and they would have discovered biochemical characteristics on the basis of which to classify species into more or less extensive groups. Moreover, this classification, as far as our actual knowledge permits such a comparison, would be identical with the system elaborated by Cuvier and his collaborators. . . . To concede that the classification of morphological groups conforms to a biochemical classification is to favor the idea that morphological and biochemical characteristics are linked together and that both are governed by the same determinism. This offers an argument for the thesis that in the last analysis evolution is directed by biochemical phenomena." (p. 120.) Of particular interest to entomologists and zoologists in general will be the author's concepts of orthogenesis. He presents data for recognition of parallel orthogenetic series in such phenomena as proteinemia, protein-sugar or combined sugar content of blood, oxyphoric and buffer capacity of blood, digestion, protein metabolism, purine metabolism, and ammonemia. Likewise of interest are his "systematic characters" for certain taxonomic groups. For example, the insects are thus characterized by the relatively high amino acid level in the blood, relatively high concentration of uric acid in the blood, and high indices for magnesium and phosphate.

The book is, in general, refreshing and stimulating although there are occasional repetitions, which, by careful planning, might have been eliminated. Also there are some rather categorical and unqualified generalizations which, in light of the present status of our knowledge, may be somewhat premature. For example, it is stated that chitin unimpregnated with salts is "a systematic characteristic of the class of insects." (p. 118.) Wigglesworth (*The Principles of Insect Physiology*, Methuen, London, 1939, p. 20), cites several exceptions. Similarly it is stated (p. 100) that invertebrate animals are "completely insensitive to the action of thyroxine." This seems somewhat precarious at the present time. (See Goldsmith, *Ann. New York Acad. Sci.* 50(5): 294-295, for summary.) However, to avoid errors of generalization in condensing material of this type is difficult. There are some debatable choices of terms and some instances of obscure expression; these are presumably the virtually inevitable consequences of translation. The number of typographical errors is not unusual for a first edition. These criticisms are in no way intended to detract from the important philosophical contributions for which the reviewer has the greatest enthusiasm. *Biochemical Evolution* presents a synthetic philosophy worthy of the attention of all aspects of biology.—DONALD S. FARNER.

ANNALS  
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No. 2

EMBRYOLOGY OF *PHAENICIA SERICATA* (MEIGEN)<sup>1</sup>

Diptera: Calliphoridae

PART III. THE GASTRULAR TUBE

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The author has previously described the embryonic development of *Phaenicia sericata* (Meigen) from the process of fertilization to the formation of the blastoderm (primary epithelium). The purpose of this paper is the presentation of the phases of development involved in the formation of the gastrular or mesodermal tube.

It has already been shown (Fish, 1947) that the cleavage nuclei migrate peripherally, the majority of them penetrating the outer layer of protoplasm, the periplasm. A nucleated coat of protoplasm, the blastema, is formed, which completely envelopes the yolk. The nuclei which penetrate and absorb the germ cell determinant of the dorso-polar surface of the posterior pole form the anlage of the germ cells. The peripheral margin of the blastema then becomes divided into cell territories by clefts. Before these clefts reach the yolk an inner layer of anucleated protoplasm, the inner periplasm, appears and merges with a medial surface of the blastema. The latter now appears doubled in thickness. The cell walls appear first on the peripheral margin of the cell territories and slowly divide the continuous portion of the blastema into separate cells. This stage is the so-called blastoderm. Except for the polar regions, where the cells are complete (the posterior pole first), the blastodermal cells still possess a narrow underlying strip of undivided protoplasm (Plate I, Figs. 1, 2, 3, 4).

THE GERM BAND

In the development of the generalized type of insect, the germ band results from a thickening of epithelial cells along the mid-ventral

<sup>1</sup>Previous articles of this series have been published under the title "Embryology of *Lucilia sericata* Meigen." The change is made here in order to conform with the current usage in David G. Hall's "Blowflies of North America."

line simultaneously with a flattening of cells of the dorsal and lateral walls of the blastoderm. In these respects *Phaenicia sericata* proves exceptional.

The process of differentiation of germ band cells from other epithelial cells of the blastoderm is the most fleeting stage so far encountered. As mentioned above the blastoderm is completed first in the posterior pole. Here also is where the germ band first becomes noticeable.

Shortly before the dorsal and lateral blastodermal cells establish walls on their bases, the epithelial cells of the mid-ventral region, about sixteen cells in width, crowd together, slowly grow in length, and gradually push into the yolk mass (Plate I, Fig. 6). The cells in the middle region of this strip push in farther than the others with the result that the peripheral margin of the ventral surface, originally convex, becomes decidedly flat (Plate II, Fig. 8). This flattening is even noticeable upon surface examination of stained whole mounts.

The epithelial cells that do not take part in the formation of the germ band do not noticeably differ from the original blastodermal cells. Those which originally overlaid the undivided protoplasmic strip have now developed an unusual attachment to it. A delicate protoplasmic stalk joins the cell base (as yet a cell membrane is not present) to the strip and each cell appears like a short stemmed goblet (Plate I, Fig. 2).

As the cells of the germ band elongate and push farther into the yolk, those on its margins undergo marked changes in their geometrical configuration. Each of these marginal cells becomes deeply curved with its concave surface contiguous with a germ band cell. The cells lateral to these marginal ones are usually curved on only one surface,

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#### EXPLANATION OF PLATE I

FIG. 1. A longitudinal section of a nearly completed blastoderm. Notice the continuous strips of protoplasm underlying all cells except for the polar regions. A—anterior; D—dorsal; N—nucleus; P—posterior; V—ventral; Y—yolk; YC—yolk cell.

FIG. 2. A highly magnified view of two blastodermal cells showing their attachment to the undivided protoplasmic strips. The "stem" of each cell is without a cell membrane.

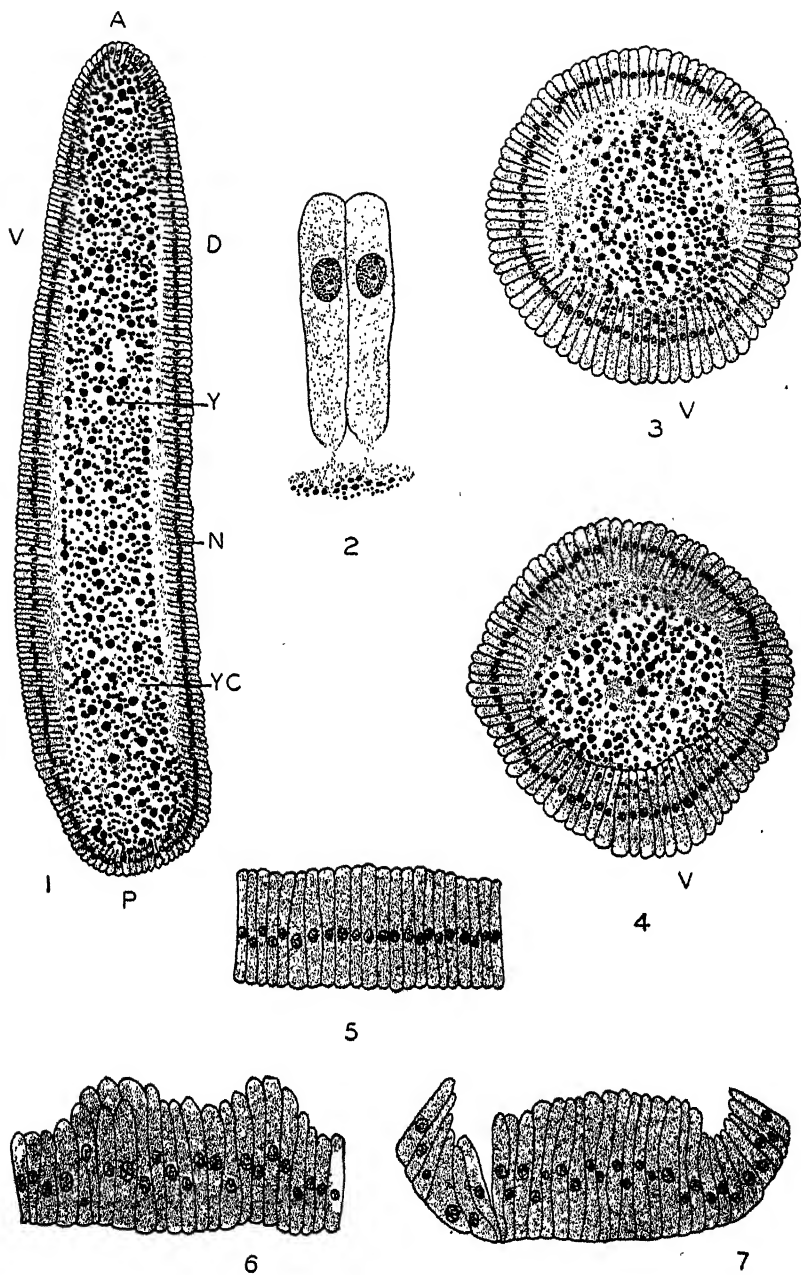
FIG. 3. A cross section of an embryo a little older than that in Fig. 1. Observe the yolk granules within the cells of the ventral region. V—ventral.

FIG. 4. A cross section of an embryo immediately prior to germ band formation. The cells of the ventral region are now complete, that is, each is completely bounded by a cell membrane. Compare this condition with that of the cells in the dorsal region. V—ventral.

FIG. 5. A highly magnified view of the cells of the ventral region of the embryo in Fig. 4. It is the first in a series of eleven illustrations (Figs. 5-15), representing the progressive changes in the transformation of a single layer of cells into a sunken tube.

FIG. 6. A slightly older stage than that in Fig. 5. The cells are more elongate and displaced towards the yolk (not shown). This is the first indication of germ band differentiation.

FIG. 7. The mid-ventral epithelial cells are now more elongate and are easily distinguished from the latero-ventral blastodermal cells. The original convex ventral surface becomes flat and the germ band is consequently more sharply defined.





the concavity towards the marginal cells. The peripheral third of these lateral cells sometimes possesses an enlargement which is hooked around the marginal cell, usually overlapping a part of the latter's peripheral edge (Plate II, Fig. 8). Proceeding laterally these scimitar shaped cells become more and more columnar until they pass insensibly into the typical epithelial cells of the lateral surface. With further germ band development the long axis of the marginal cells comes to lie almost in the same plane as the peripheral margin of the germ band. The space these cells occupied (they originally contacted the yolk) is assumed by the germ band cells.

The next area of the blastoderm to differentiate is the ventral region of the posterior portion of the anterior third of the blastoderm. The same cell configurations as are apparent in the posterior pole are also apparent here. The germ band now proceeds in two directions, anteriorly from the posterior pole and posteriorly from the anterior pole. The last portion of the ventral region to differentiate is the posterior portion of the anterior half of the blastoderm. However, before this final differentiation is accomplished, the gastrular invagination begins in the posterior region of the germ band.

Grabber and others have designated the undifferentiated cells of the original blastoderm, since they function as an envelope of the yolk, the serosa. According to their views the differentiation consists of a thinning of the dorsal and lateral sides rather than a thickening of the ventral side.

#### FORMATION OF THE GASTRULAR GROOVE

In the insects, as a consequence, at least in part, of the large amount of yolk, the phases of gastrulation and layer formation, as concerns phylogeny, are extremely modified and therefore difficult to interpret. The problem centers about the fact that here the invagination gives rise to a cell layer which later differentiates into tissues typically of mesodermal origin instead of a gut epithelium. For this reason objec-

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#### EXPLANATION OF PLATE II

FIG. 8. The germ band prior to invagination. Observe the configuration of the marginal and ventro-lateral cells. MC—marginal cell.

FIG. 9. The middle portion of the germ band remains in position while the two lateral portions form shallow pockets. This is the first indication of invagination.

FIG. 10. The two lateral pockets narrow and deepen while the middle cells of the band begin to sink inwardly.

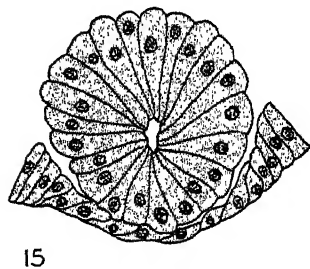
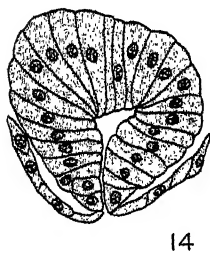
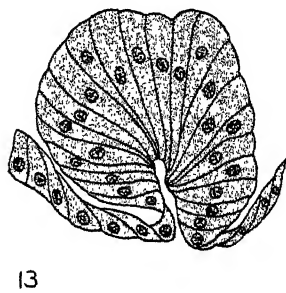
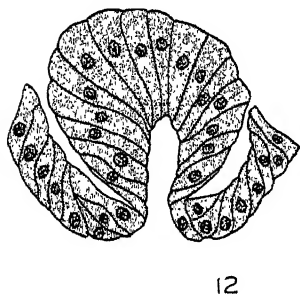
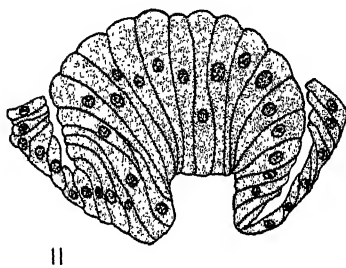
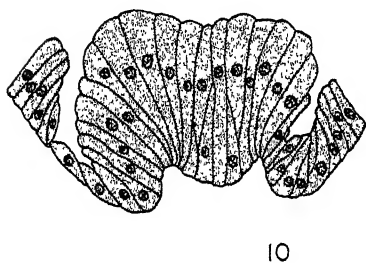
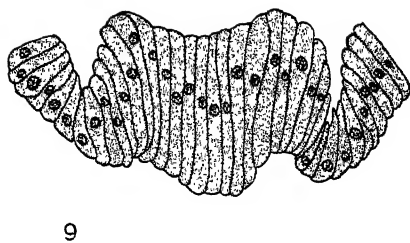
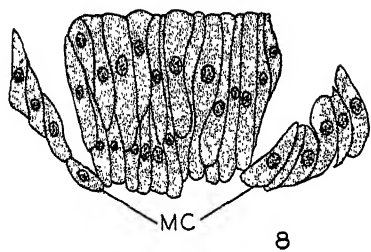
FIG. 11. The middle cells of the band have sunk farther into the yolk forming a single wide furrow.

FIG. 12. The groove is now deep. The cells of the invaginated area are typically wedge-like.

FIG. 13. Closure of the groove begins.

FIG. 14. Closure is almost complete. Notice that it has been accomplished by the cells of the furrow itself.

FIG. 15. The completed gastrular or mesodermal tube. Notice the small lumen and the flat layer of cells covering the tube.



tions have been raised, in reference to the Arthropoda, as to the validity of the use of the terms gastrulation and gastrula (cf. Chapter VI, Johannsen and Butt, 1941). In this and future papers, the term gastrulation will be used to mean an invagination which results in a differentiation of germ layers, regardless of the subsequent fate of these layers.

With few exceptions gastrulation in insects takes place soon after the germ band has formed. There are two major types of layer formation. In the first type the middle portion of the germ band sinks into the yolk, forming a deep furrow which is converted into a sunken tube. This tube flattens out into a two layered sheet of cells, the inner or lower layer. In the second type the edges of the lateral portions of the germ band grow and separate from the middle portion of the band and then grow together beneath it. The middle piece, now cut off from the lateral portions of the band, forms a single sheet of cells. The type of gastrulation in *Phaenicia sericata* conforms to the first type mentioned.

The steps involved in the development of the gastrular tube may be conveniently divided into two phases; (1) the formation of the ventral groove or furrow, and (2) the closure of the groove.

As mentioned above the invagination of the germ band occurs first in the posterior third of the blastoderm. The speed of band formation and the fact that the ventral furrow is present in both polar thirds before the germ band is formed in the mid-ventral region, suggests that invagination must follow immediately (a minute or two at the most) after band development. As seen transversely the middle part of the band is not the first part to sink into the yolk as is commonly accepted in muscid development. If the stages are observed in the very beginning it will be noticed that two small lateral pockets are present, below and slightly medial to the space formerly occupied by the marginal cells of the germ band (Plate II, Figs. 9, 10). The middle portion of the band still maintains its original position. The originally flat surface of the germ band bordering the yolk now has a definite shallow depression in its middle portion. The middle part

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#### EXPLANATION OF PLATE III

FIGURES 16-33 represent cross-sectional serials of two entire embryos of slightly different ages from anterior to posterior. There are eight illustrations of the first embryo, completed with Fig. 23. The total length of this embryo is about 1270 microns.

FIG. 16. About 200 microns from the anterior pole. The germ band has started to form in the ventral region. V—ventral.

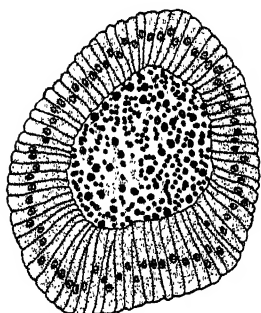
FIG. 17. About 470 microns. The germ band is more pronounced.

FIG. 18. About 520 microns. The band is not yet developed in this region (slightly anterior to the middle).

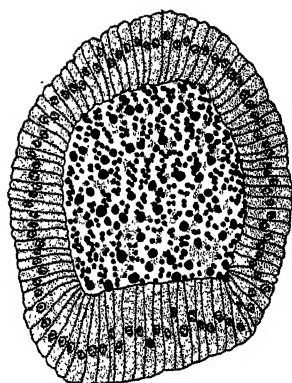
FIG. 19. About 680 microns.

FIG. 20. About 800 microns. The middle cells of the band have sunk into the yolk.

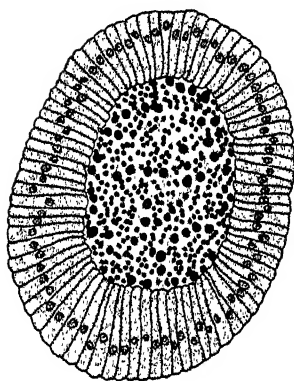
FIG. 21. About 870 microns. A typical invagination is present.



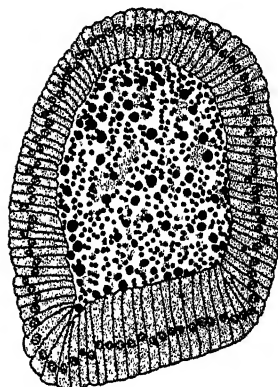
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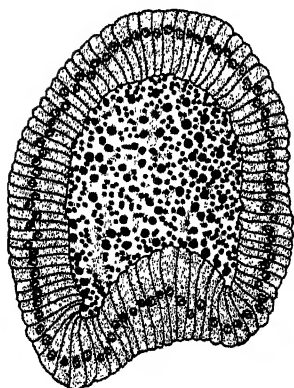
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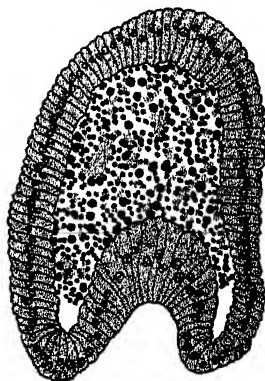
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of the band then sinks into the yolk, establishing a relatively wide furrow (Plate II, Fig. 11). The depression in the mid-region of the band contiguous with the yolk now becomes convex and a typical invagination is present. The middle region apparently continues to sink inwardly and at the same time the groove begins to narrow. A few sections indicate that the elongation of the groove is not a consequence of the middle cells sinking inwardly but rather that the lateral areas grow downward and towards each other. Perhaps it is a result of both processes.

From the initial point of invagination the furrow proceeds both anteriorly and posteriorly. I have not observed a groove originating in this manner in the very tip of the posterior pole. The posterior portion of the furrow is relatively narrow and shallow.

The gastrular groove does not proceed as a continuous furrow to the anterior portion of the blastoderm. Shortly after invagination in the posterior region, the anterior third of the band sinks into the yolk (Plate VI, Fig. 34). Its groove courses both anteriorly and posteriorly. All my sections indicate that it does not attain the sharp curvature of the anterior pole. The posterior portion of the anterior third of the groove widens and two large lateral diverticula appear (Plate VI, Fig. 36). Posteriorly it continues until it meets the posterior furrow, usually near the middle portion of the germ band. This area of fusion is not always uniform.

These stages of development are accompanied by the appearance of one pair of oblique head folds, two transverse folds girdling the posterior portion of the anterior half of the egg and usually three pairs of lateral oblique folds. The dorso-lateral margins of these paired oblique folds never fuse dorsally. In some cases smaller folds may be temporarily present.

#### CLOSURE OF THE GROOVE

It is perhaps unusual that such a fundamental process as closure of the ventral furrow is not uniform even in embryos with the same parents. The more common type is that described below. Instead of the approach and union of the marginal cells as a method of closing the groove, the closure is made by the cells of the wall of the furrow.

As viewed transversely, the invaginated portion of the embryo can now be divided, for purposes of discussion into four regions: (1)

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#### EXPLANATION OF PLATE IV

FIG. 22. (Continued from PL. III). About 970 microns.

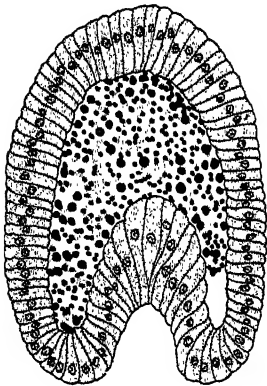
FIG. 23. About 1130 microns. There is some indication of invagination near the posterior pole.

FIG. 24. The first in a series of sections of an older embryo (total length about 1000 microns) taken about 110 microns from the anterior pole. The germ band has not developed here as yet.

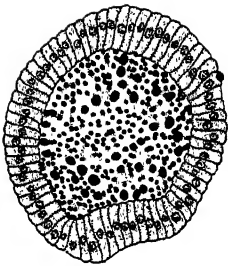
FIG. 25. About 160 microns. Notice the clustering of cells at the anterior limit of the gastrular groove.

FIG. 26. About 195 microns.

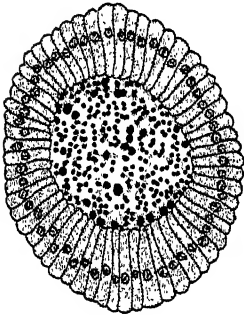
FIG. 27. About 215 microns.



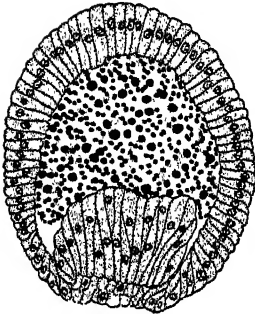
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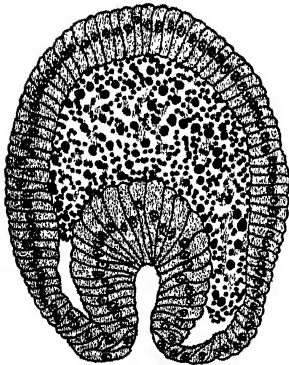
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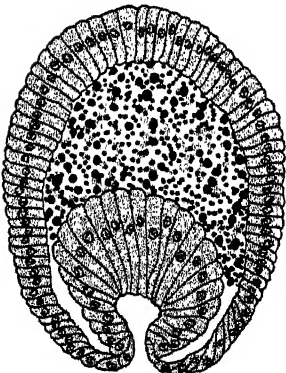
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a thick medial portion bounded internally by the yolk, (2) two lateral portions bounded primarily by the cells of the latero-ventral walls of the blastoderm, and (3) the furrow or groove. Shortly after the groove is about the thickness of a single cell, (Plate II, Fig. 13) a group of about five cells of each lateral portion of the invaginated portion grow towards each other and eventually fuse on the mid-ventral line (Plate II, Fig. 14). This line of fusion lies in the midline of the area formerly occupied by the furrow itself. Gradually the cells of the invaginated area assume a radial disposition forming a thick-walled tube, the gastrular or mesodermal tube (Plate II, Fig. 15). The marginal curved and scimitar-shaped cells originally bordering the germ band now seem to be pulled towards the invaginated area with the result that they temporarily form a flat covering of the gastrular tube. There are about four of these cells on each side of the mid-ventral line (Plate II, Fig. 15).

In general the ventral groove closes first in that region of the embryo where the germ band and furrow were first developed (Plate VI, Fig. 35). It closes last in the region of the head fold just prior to the formation of the amnion. In several embryos closure did not occur at any level until the posterior mesenteron rudiment was well developed.

To avoid excessive repetition, the subject of yolk and germ cells will be discussed in Part IV, together with the inner layer and mesenteron rudiments.

#### SUMMARY AND CONCLUSIONS

1. The germ band is formed by an elongation of a strip of ventral blastodermal cells rather than a flattening of cells of the dorsal and lateral regions of the blastoderm.
2. The germ band is developed first on the ventral surface of the posterior third of the blastoderm and last in the middle region of the blastoderm.
3. Invagination occurs first in the posterior third of the germ band and last in the middle area of the band.
4. The first cells to sink into the yolk are those of the lateral portions of the germ band.
5. The non-embryonic portions of the embryo exhibit six folds.
6. Closure of the groove, a fusion of the cells of the lateral walls of the furrow, results in a long hollow sunken tube.
7. The ventral groove closes first in the posterior region. In the head fold region it remains open until shortly before the formation of the amnion.

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#### EXPLANATION OF PLATE V

FIG. 28. About 295 microns.

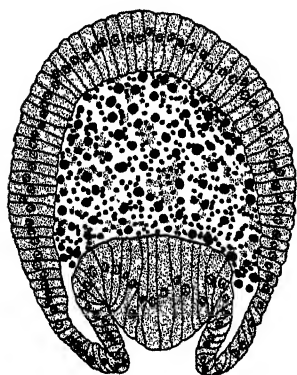
FIG. 29. About 355 microns.

FIG. 30. About 595 microns.

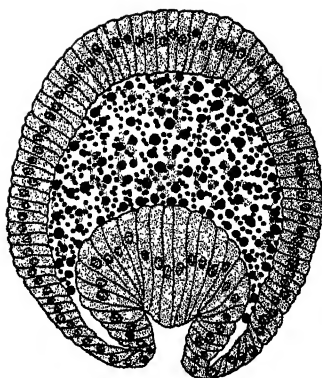
FIG. 31. About 705 microns. The groove is almost closed.

FIG. 32. About 845 microns. The groove is open and shallow.

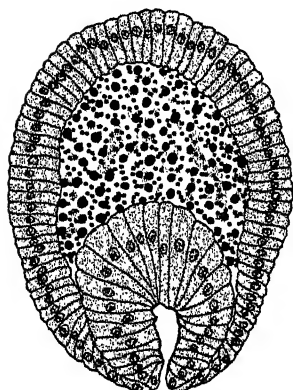
FIG. 33. About 890 microns.



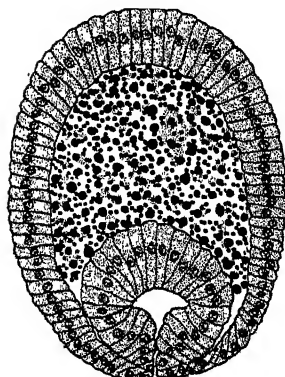
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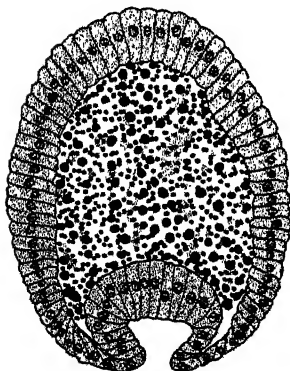
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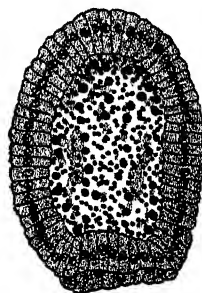
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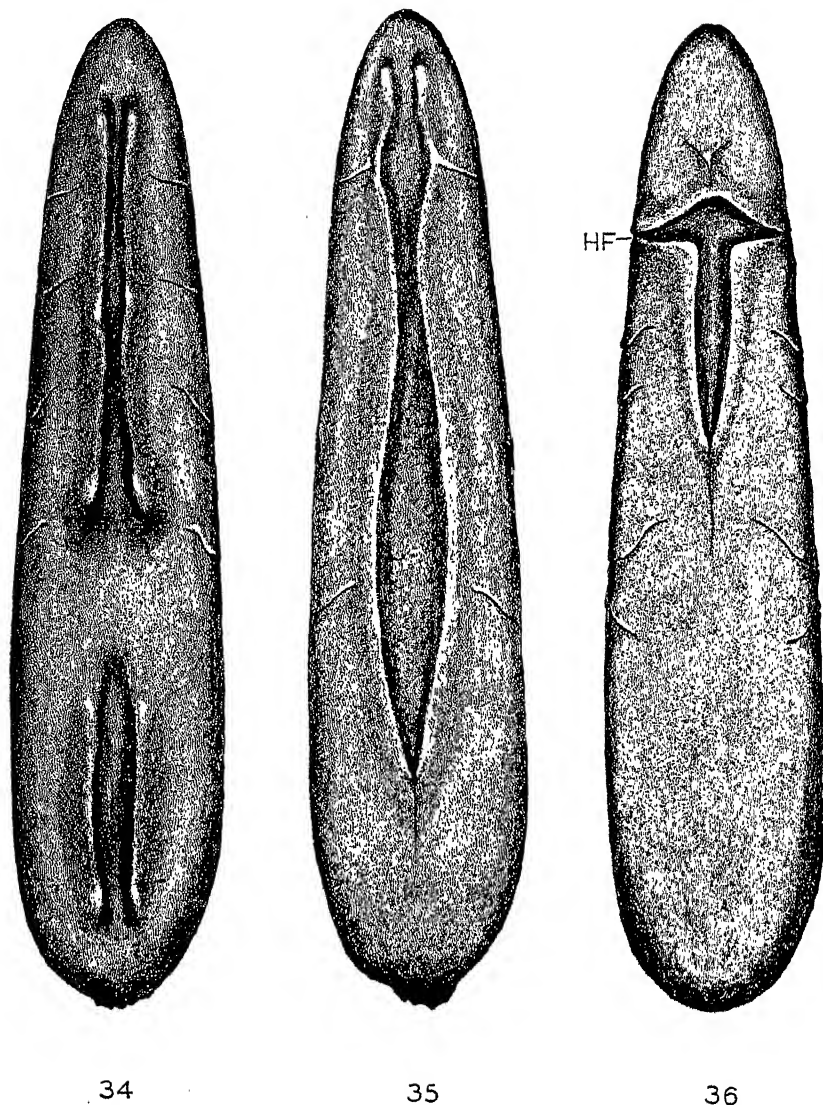


Plate VI has three drawings of stained whole mounts as viewed under reflected light. None of these is the same developmental age as those in the serial sections.

FIG. 34. An early stage in gastrulation, showing two furrows. The one in the posterior region is the older.

FIG. 35. A more advanced embryo showing the invaginated region and the closure of the posterior furrow.

FIG. 36. A still older embryo showing paired lateral folds. In the region of the head fold, paired lateral diverticula of the invagination have developed. HF—head fold.

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Y AN INTRODUCTION TO THE GENETICS OF HABROBRACON JUGLANDIS (ASHMEAD), by ALBERT MARTIN, JR. The Hobson Press, New York. xii + 205 pages, 19 illustrations and three tables. 1947. Price, \$3.50.

This book, one of relatively few of its kind, brings together information on both the genetics and general biology of a well known species, in this instance the parasitic wasp *Habrobracon juglandis* (Ashmead) (= *Microbracon hebetor* [Say]). It is, as its author states, a summary designed for students of Habrobraconology. Although it is intended primarily as a text, its scope and design make it useful as a reference as well, both for entomologists interested in the genetical aspects of their subject and for geneticists interested in entomological aspects of theirs. The introduction includes, among other things, statements on systematics, distribution, reproduction, development and metamorphosis. Descriptions of size, color, external morphology, internal and external genitalia, sex differences and sex reactions of adults follow, together with a brief account of gametogenesis in relation to oviposition and development. Methods (and precautions) for culturing both the wasp and its host are concisely stated; also included are a brief life history, methods of examination and preservation, and methods of recording data. A descriptive list of more than a hundred spontaneous, x-ray-induced, and thermally-induced mutations is given. Normal sex conditions and their deviates (gynanders and other mosaics, intersexes, impaternate females, zygous males, etc.) are discussed, and their relations to mode of reproduction, ploidy, mutation, degree of relationship of parents, variations of sterility, cell size, secondary sex characters, sex reversal and sex behavior are emphasized. Various theories of sex determination (to date the central problem in genetic research on *Habrobracon*) are reviewed and the complementary factor and multiple sex allele theories are clearly and concisely set forth, together with their supporting evidence. The question is raised whether these theories, now experimentally verified for *Habrobracon*, may be extended to the Hymenoptera in general. The formula for the possible number of different females in a series of  $n$  alleles should be  $(n^2-n)/2$  instead of  $(n^2-n)/2$ , obviously a typographical error (p. 95). The four now known linkage maps (10 are possible, since  $2n=20$ ) are discussed with special reference to the history of their construction; methods of detecting and measuring linkage, with some modifications necessary for *Habrobracon*, are systematically treated. It is shown that *Habrobracon* is highly responsive to different conditions of environment, and variations of eye color, body color, body size, fecundity, hatchability, behavior, development, mutation, sex ratio and gametogenesis are discussed in relation to such factors as temperature, humidity, irradiation and quantity of food. In conclusion, the author reviews some of the advantages of *Habrobracon* for genetic research and points out a number of interesting problems awaiting investigation.

A number of useful illustrations and tables are included, together with an especially valuable glossary. The bibliography is extensive and includes a number of important and useful references in addition to those on *Habrobracon*. Abundant text citations greatly facilitate reference to original papers.—RAY MOREE.

# VARIATIONS, DURING DEVELOPMENT, IN THE RESISTANCE OF THE GRASSHOPPER EGG TO A TOXIC SUBSTANCE

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## INTRODUCTION

In a series of experiments with dyes it has been shown that the hydropyle of the grasshopper egg, and certain of the other egg coverings as well, undergo striking changes as development proceeds (Slifer, 1949). During the first five days, at 25°C., after it is laid only the chorion of the intact, living egg stains and no dye passes beyond the thin, primary wax layer<sup>1</sup> which waterproofs the inner surface of the shell. As soon as the hydropyle is secreted (as a part of the chitinous cuticle) between the 5th and 7th days the primary wax layer breaks down and dyes are then able to reach the newly-formed hydropyle and to stain it. Before diapause sets in, ten to twelve days later, the hydropyle loses its capacity for staining. This is due to the waterproofing, at this time, of the outermost portion of the hydropyle by a secondary wax or wax-like layer which is secreted by the hydropyle cells. This layer protects the egg during diapause throughout which period the hydropyle is highly resistant to staining. Towards the end of diapause the secondary wax layer is disrupted and during the later stages of development the hydropyle again stains readily. The dyes which were used penetrate only so far as the inner edge of the striated layer of the hydropyle and have no effect on the embryo which continues its development unharmed.

The experiments just summarized demonstrate the occurrence of permeability changes in the hydropyle and other structures but they present one disadvantage. The penetration of dyes is slow, requiring a week or more for satisfactory results, and, since the egg continues to develop during this time, it is not possible to decide with much exactness just when a change takes place. A better material than a dye for this purpose would be one (1) which would not affect the diapause hydropyle but (2) which would both stain and penetrate that of the developing egg and (3) which would be sufficiently toxic to stop development and kill the embryo after passing through the hydropyle. After trying a variety of substances, a solution of iodine in potassium iodide was found to meet these requirements. The results of experiments with this solution are presented below.

## MATERIALS AND METHODS

*Melanoplus differentialis* eggs of the desired age and with a known temperature history were removed from their pods and all debris and

<sup>1</sup>Beament (1946a, 1946b, 1946c, 1948) has described the waterproofing of the egg of *Rhodnius prolixus* by thin layers of wax and Slifer (1946, 1948b, 1949) has reported the presence of wax layers in the egg of *Melanoplus differentialis*.

spoiled eggs discarded. The sound eggs remaining were washed repeatedly with distilled water, and, if the eggs were old enough, a sample was dissected to be certain that the embryos had reached the expected stage of development. From 40 to 100 eggs—the number depending upon how many were available—were then placed in a 50 cc. Erlenmeyer flask and enough of a 1% solution of iodine in 10% potassium iodide added to cover the eggs about half way. The flasks were corked and set in an incubator kept at 25°C. Each day or, at most, every other day, the flasks were filled to the top with distilled water. This was poured off at once and insured a complete change of the gases inside the flasks. Fresh I-KI solution was then added and the flasks corked again and returned to the incubator. On the 5th day the eggs were removed from the flask and the extent to which the iodine had affected each egg determined. Eggs less than 10 days old, in which the chitinous cuticle had not yet formed, or was still delicate, were dissected in Ringer's solution and the embryo (if present), yolk, membranes and shell examined. Those over 10 days old were dried thoroughly on filter paper and then placed in a dish of xylol. Here the chorion was removed (Slifer, 1948a) and the condition of the hydropyle, egg contents, etc., noted. In a small number of eggs in some experiments iodine entered through minute injuries or imperfections in the chitinous cuticle. If the hydropyle had retained its natural color such eggs were classed with those which had not been affected by the iodine.

#### RESULTS

*Eggs one to five days old.*—The effects of an I-KI solution on young eggs in which the chitinous cuticle has not yet formed are extremely interesting. All who have handled eggs less than five or six days old know that they are very soft and easily damaged. In spite of this these eggs are highly resistant to the entrance of iodine (Fig. 1). The chorion itself stains deeply, the color moving gradually forward from the posterior end where minute pores are present in the exochorion (Slifer, 1949), but the primary wax layer on the inner surface of the chorion prevents the iodine from passing into the yolk.<sup>2</sup> Development soon stops in such eggs and this suggests that at least small quantities of the iodine or potassium iodide may reach the interior of the egg; but the yolk remains normal in color and consistency. This surprising resistance to the penetration of iodine correlates nicely with the facts, already known, that the eggs do not take up water during this period (Slifer, 1938) and that dyes will not pass beyond the inner surface of the chorion (Slifer, 1949).

*Eggs from five days old to diapause.*—Water absorption by the egg begins towards the close of the 1st week at 25°C. and this coincides with the formation of the chitinous cuticle with its specialized area, the hydropyle (Slifer, 1938). Evidently the primary wax layer, in some way as yet unexplained, breaks down or is disorganized and

<sup>2</sup>If these eggs are dried, treated with xylol for 15 minutes and then examined, the yolk will be found colored brown by the iodine. As soon as the wax layer is destroyed, the iodine passes rapidly from the chorion into the egg contents. Comparable results were obtained with dyes (Slifer, 1949).

from then on the egg is protected, instead, by the tough, resistant chitinous cuticle which, except at the hypopyle, is highly impermeable. During the fifth, sixth, and seventh days at 25°C., while the hypopyle is being secreted, the resistance of the egg to iodine drops sharply and by the 8th day iodine is found coloring the hypopyle of every egg (Fig. 2). The hypopyle in some eggs stains intensely over its whole surface while others show patches of various shades of reddish-brown on an unstained background. Between the tenth and twentieth days at first in an increasing and later in a decreasing number of eggs the iodine passes through the hypopyle and damages the egg contents (Fig. 1). The maximum effect is found about the sixteenth day. The yolk in such eggs is darkened and the embryos are hardened, sometimes brown in color, and, quite obviously, dead. Development is usually also arrested in those eggs which show discoloration only at the hypopyle. This may be due to the entrance of small but toxic quantities of the iodine and potassium iodide or to the inability of the

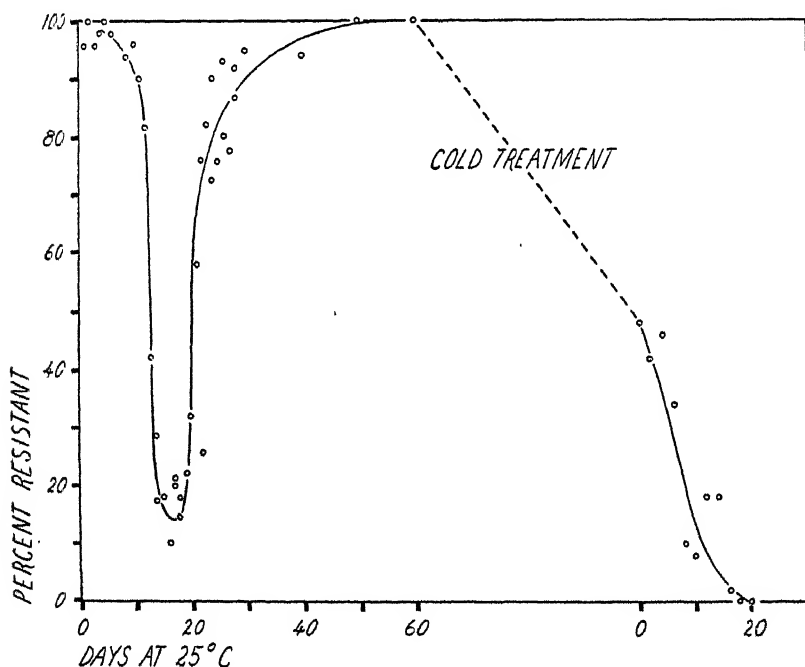


FIG. 1. Penetration of iodine into egg contents. Eggs of *Melanoplus differentialis* of various ages treated with a 1% solution of iodine in 10% potassium iodide for five days at 25°C. Diapause begins near close of third week. Broken line represents time spent at 5°C., (usually four months) during which diapause was broken. Hatching starts 18 to 20 days after cold-treated eggs are returned to 25°C. Abscissa: days at 25°C., since eggs were laid (left side of graph) or since eggs were removed from cold (right side of graph). Ordinate: percentage of eggs with no iodine visible in egg contents.

egg to take up water from a solution of this concentration. Probably both have an effect.

This extreme susceptibility of the egg to iodine persists until the close of the second week at 25°C. Then, beginning about the fifteenth day a few eggs show no discoloration of the hydropyle after five days in the iodine solution (Fig. 2). Throughout the next week the resistance to iodine rises at first slowly and then more rapidly. An examination of the curves in Figures 1 and 2 suggests, at first glance, that the onset of iodine resistance is gradual. Another interpretation, however, is possible. The eggs in any lot, no matter how carefully selected at the beginning of an experiment, do not develop at exactly the same rate (Slifer, 1932). A very few will be farther along than expected and a larger number will lag behind. It is quite possible, then, that the rising portions of the curves shown in Figures 1 and 2 are composite and that the actual onset of resistance in any single egg occurs within a much shorter time.

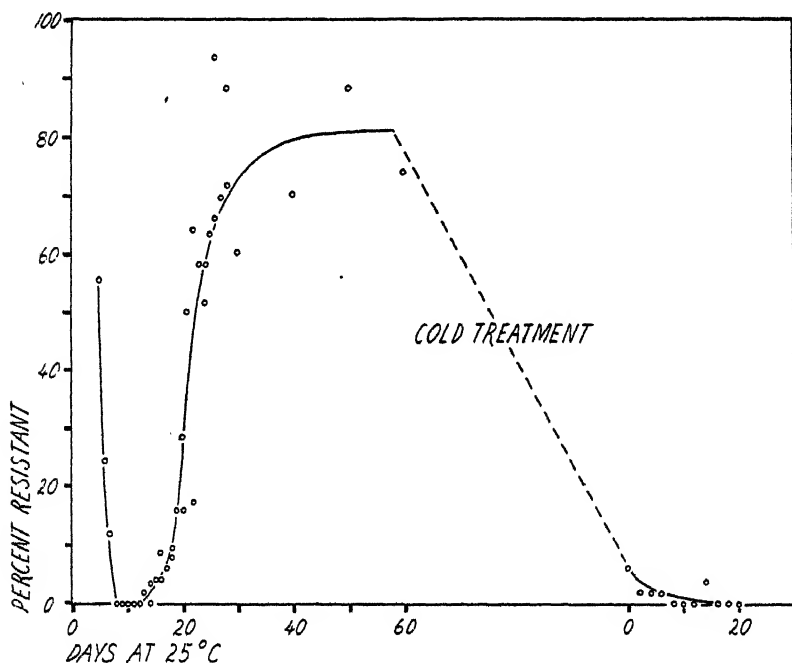


FIG. 2. Resistance of hydropyle to staining by iodine. Eggs of *Melanoplus differentialis* of various ages treated with a 1% solution of iodine in 10% potassium iodide for five days at 25° C. Diapause begins near close of third week. Broken line indicates time spent at 5° C., (usually four months) during which diapause was broken. Hatching begins 18 to 20 days after cold-treated eggs are returned 25° C. Abscissa: days at 25° C., since eggs were laid (left side of graph) or since eggs were removed from cold (right side of graph). Ordinate: percentage of eggs in which hydropyle retains its natural color.

*Eggs in diapause.*—During diapause only a small percentage of the eggs treated with iodine solution show any discoloration of the hypopyle<sup>3</sup> and the great majority of them show no effect of the reagent (Figs. 1 and 2) aside from the browning of the chorion. If diapause eggs which have been in an I-KI solution for five days and which have retained the natural pale brownish-yellow color of the hypopyle are treated with xylol to break diapause (Slifer, 1948a), dried and incubated at 25°C. on moist filter paper almost every one will be found to be developing and the majority ready to hatch three weeks later (Table I). Diapause eggs, then, are highly resistant to iodine solution. This contrasts sharply with their behavior in the period before diapause begins.

*Eggs with diapause broken by xylol.*—Since treatment with xylol or other wax solvents breaks diapause (Slifer, 1946, 1948a) one would

TABLE I

## EFFECTS OF IODINE SOLUTION ON VIABILITY OF DIAPAUSE EGGS

Two hundred 45-day-old diapause eggs selected for presence of partially pigmented eyes at posterior end. One hundred of these in 1% iodine in 10% potassium iodide solution for 7 days at 25°C. Examined and 86 found with natural colored hypopyle. These treated for 30 minutes with xylol to break diapause, dried and incubated on moist filter paper at 25°C., for 20 days. One hundred control eggs on moist filter paper at 25°C., for duration of experiment.

	Eggs Developing	Eggs Still in Diapause	Eggs Spoiled	Percent of Viable Eggs Developing
I-KI treated eggs	81	3	2	96.4
Control eggs	0	97	3	0.0

expect that eggs exposed to such reagents would be particularly susceptible to injury by iodine. This proves to be the case. If diapause eggs which have been treated with xylol are dried thoroughly and then placed in I-KI solution the hypopyle of each turns a very dark brown or black and the iodine promptly passes into the egg, discolors the yolk and kills the embryo. With the waxy layer which normally protects it dissolved away, the egg quickly succumbs to this toxic substance.

*Eggs with diapause broken by cold.*—The reaction of grasshopper eggs to iodine solutions during the later stages of development was studied with eggs in which diapause had been broken by exposure to low temperatures (approximately 5°C.) for several months. Their behavior (Figs. 1 and 2) was found to be very similar to that of eggs which had not yet reached diapause. The hypopyle of every or very nearly every egg was stained by the iodine (Fig. 2) and a large percentage, after five days in the solution, contained dead embryos and badly discolored yolk (Fig. 1). The wax layer at the hypopyle has been disorganized or broken down during the prolonged exposure of these

<sup>3</sup>It is possible that in those eggs which do show some discoloration, the wax which is secreted into the outer layer of the hypopyle by the cells below it has not penetrated all the way to the outer surface at every point.

eggs to cold and is, consequently, no longer able to prevent the entrance of iodine. The hydropyle remains in this condition until the egg hatches.

An interesting phenomenon was noted in cold-treated eggs which had been allowed to develop for eight days, or longer, at 25°C. and were then exposed to a solution of iodine. The pleuropodia (which are responsible for the production of the hatching enzyme (Slifer, 1937) ) and the region of the chitinous cuticle which is in contact with them turn brown in these eggs. This occurs before any signs of injury to the embryo are apparent and while the dorsal body wall, where the heart is forming, is still beating regularly and vigorously. Apparently some component of the secretion which is produced by the pleuropodia is readily affected by traces of iodine.

#### DISCUSSION

The egg of *Melanoplus differentialis*, at 25°C., passes through the following stages:

1. *First to fifth day.* Primary wax layer on inner surface of the chorion waterproofs the egg. No water absorbed during this period.
2. *Fifth to about the sixteenth day.* Chitinous cuticle, including the hydropyle, secreted by the serosa. Primary wax layer disrupted and water is then absorbed through the hydropyle.
3. *Diapause.* Secondary wax layer secreted and waterproofs hydropyle. Water absorption stops.
4. *End of diapause to hatching.* Secondary wax layer breaks down and water is again taken up through the hydropyle.

During two periods in their development, then, *Melanoplus differentialis* eggs, protected by thin layers of wax or wax-like substances, are resistant to the entrance or loss of water and during two other periods, when the wax layers are imperfect, water is taken up by or passes out of the egg very readily.

In the present experiments the reaction of the egg to iodine solutions at any particular stage has been found to be closely correlated with its permeability to water at that time. During the first five days of development no iodine can be seen inside the egg even after several days exposure to that reagent. The protection afforded by the primary wax layer on the inner surface of the chorion is surprisingly effective considering the fact that it is probably less than  $0.2\mu$  in thickness (Slifer, 1948b); but this protection is not quite perfect for development stops in these eggs even though no iodine is visible inside them. During diapause the thick, tough, impermeable chitinous cuticle and the hydropyle with its outer layer waterproofed by a waxy material entirely prevent iodine from reaching the egg contents. The embryos in the egg show no signs of injury and, when diapause is broken, resume development and hatch.

During the second and fourth periods, on the other hand, the effects of iodine on the egg are altogether different. These are periods of water uptake. With the wax seal on the hydropyle still incompletely formed (period 2) or partially disrupted (period 4) iodine is now able to penetrate the hydropyle and to reach the egg contents. Of the eggs treated with iodine during these two stages, a very high percentage is promptly killed.



A knowledge of the fact that at two particular periods in their development the eggs of this species of grasshopper are susceptible to the action of a toxic agent while at others they are highly resistant to it may be of some interest to those who are working in the field of applied entomology.

#### CONCLUSIONS

1. The primary wax layer on the inner surface of the chorion of the *Melanoplus differentialis* egg acts as a barrier to the passage of iodine (dissolved in a solution of potassium iodide) during the first five days after the eggs are laid. However, traces of iodine or potassium iodide probably do penetrate the wax layer for development stops in these eggs even though no effect on the yolk can be seen.

2. From the fifth to about the sixteenth day at 25°C. the eggs are highly susceptible to iodine poisoning and the newly-formed hydropyle is discolored by this substance as it passes through it into the yolk and kills the embryo.

3. During diapause the hydropyle, now protected by the secondary wax layer, is not stained or penetrated by iodine and the eggs are entirely unharmed even after long exposure to this reagent.

4. When diapause is over the hydropyle again stains readily in a solution of iodine and the iodine passes through it, darkens and coagulates the yolk and kills the embryo.

5. There is a close correlation between the permeability of the hydropyle to water, the presence of a layer of wax or wax-like material and the susceptibility of the eggs to injury by iodine.

6. A knowledge of the periods when the eggs are least resistant to a toxic agent may be of some value to those who are interested in the control of grasshoppers.

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# PARASITES OF THE EUROPEAN CORN BORER IN DELAWARE<sup>1</sup>

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Since the discovery of the European corn borer, *Pyrausta nubilalis* (Hbn.) in Delaware in 1934, this insect has increased in numbers until it is now the most important pest of corn in the State. In the past, the only available control methods have been cultural practices—the destruction of overwintered borers, the use of resistant varieties, and the adjustment of planting dates to avoid losses caused by attacks of the first-brood larvae. Insecticides, effective for corn borer control, are of comparatively recent origin. Furthermore, until very recently, there has been no equipment capable of applying insecticides successfully to corn after it had reached the tasseling stage.

In the search for methods of reducing the borer population, the establishment of natural enemies of this introduced pest has received consideration. Large numbers of parasites have been released in Delaware during the period 1941–1946<sup>4</sup>. Information that has been gathered relative to their abundance from the time of release through 1947 provides a basis for the present report.

The utilization of parasites has an advantage, in that once successfully established, they continue to destroy a certain proportion of the borers without further aid from man. Their continued presence after colonization is subject, naturally, to many factors, any one of which may reduce their numbers or even eliminate them. Among unfavorable and limiting conditions are weather, attack by secondary parasites, and poor synchronization with the host insect.

## COLONIZATION OF PARASITES

The Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, has imported and successfully established several foreign parasites that have proved to be effective enemies of the European corn borer.

In 1941, representatives of the Bureau from the Moorestown, New Jersey, laboratory liberated small colonies of *Macrocentrus gifuensis* Ashm. at Kirkwood, Dover, and Stockley, thus providing a possible nucleus of this species in each county. The tachinid fly, *Lydella stabulans*

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<sup>4</sup>All parasites were obtained from, and all corn borer larvae processed by, the European Corn Borer Laboratory of the U. S. Bureau of Entomology and Plant Quarantine, Moorestown, New Jersey.

was divided into 24 segments of 3.14 square miles each. Collections in this and subsequent years were made from the central area and all odd-numbered segments.

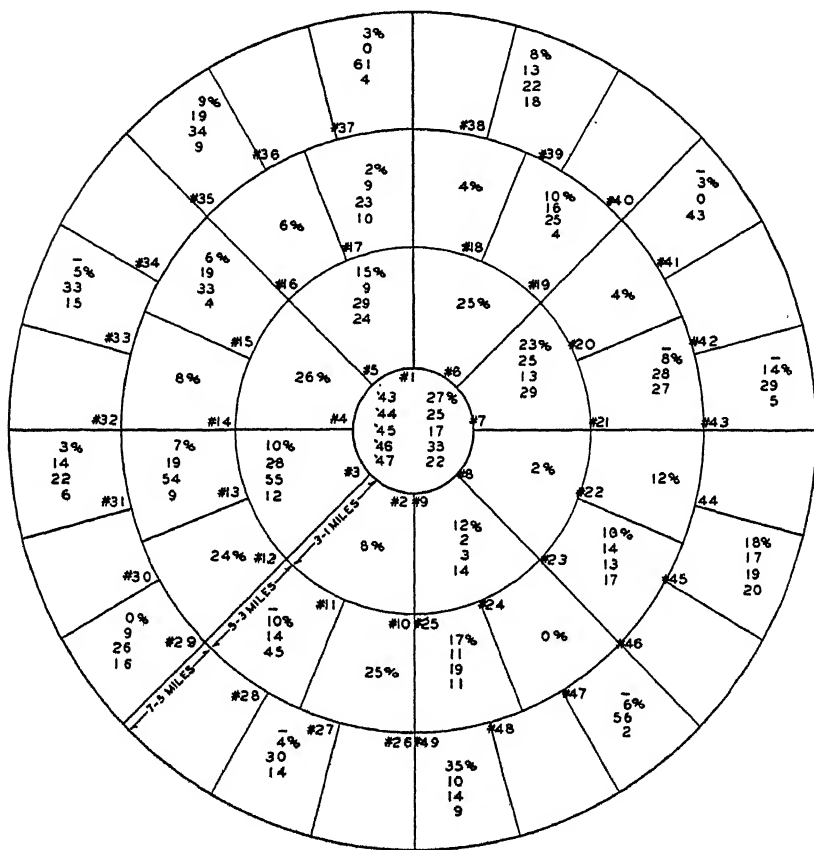


FIG. 1. Diagram of Stockley special-study area, showing percentage of European corn borer larvae parasitized, years 1943 to 1947, inclusive. Parasites were colonized at the center of the inner circle. Borer collections were made in 1943 in the central area and in all even-numbered segments, while those in subsequent years were made in the central area and in all odd-numbered segments. A dash in any percentage column indicates no collection.

A similar study-area was established at the Kirkwood colonization site in 1945 (fig. 2). As with the Stockley area, the seven-mile circle was not utilized until the second year. Here, as well as at Stockley, borer samples consisted normally of 50 full-grown larvae. In several instances, however, the number actually secured was below this, due

either to the limited amount of corn grown in a segment, or to a low rate of borer infestation.

In addition to the Stockley and Kirkwood liberation points, parasites were released at seven other sites in the State; namely, Hockessin, Townsend, Dover, Frederica, Farmington, Milton, and Laurel. At

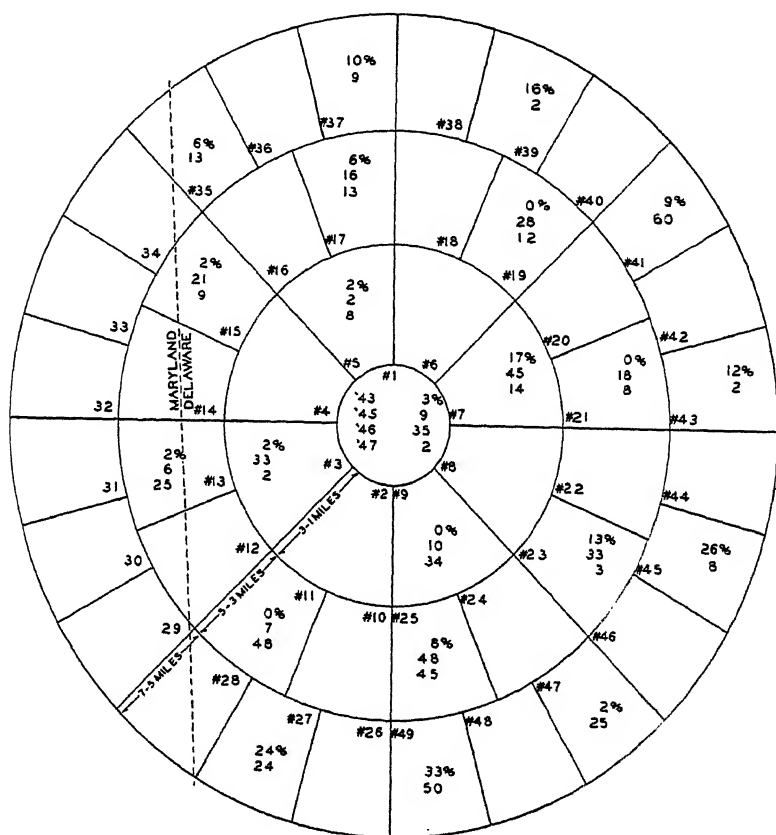


FIG. 2. Diagram of Kirkwood special-study area, showing percentage of European corn borer larvae parasitized, years 1943, 1945, 1946, and 1947. Parasites were colonized at the center of the inner circle. Collections in five- to seven-mile zone, years 1946 and 1947 only.

each of these locations, collections of 200 borers were made during 1945 and 1946. These locations are indicated in figure 3.

In 1945, an additional effort was made to obtain data on parasitism of borer larvae without regard to the parasite release points. Accordingly, 50-borer collections were made at approximately 10-mile intervals

along the main highway from Claymont in the north to Rehoboth in the south. These collection points are shown in figure 4.

In 1947, the U. S. Bureau of Entomology and Plant Quarantine devised a uniform plan of sampling which was to be followed in the states along the Eastern Seaboard. The State was divided into sections 10 miles square (fig. 5), or fractions thereof resulting from irregularities in the boundary lines. Fifty-borer samples were obtained from near the center of each of 30 such squares.

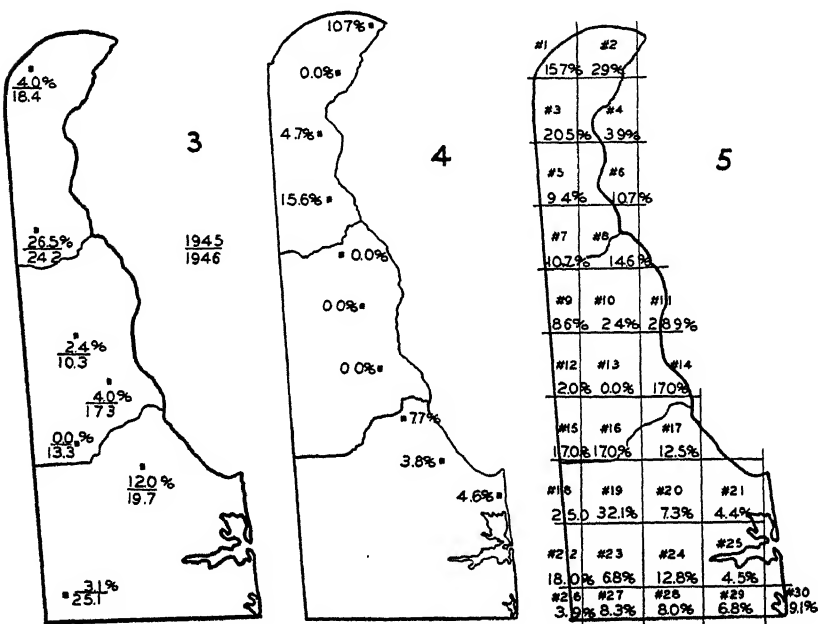


FIG. 3. Percentage of European corn borer larvae parasitized at seven release points in Delaware, 1945 and 1946.

FIG. 4. Percentage of European corn borer larvae parasitized at supplementary collection points, Delaware, 1945.

FIG. 5. Percentage of European corn borer larvae parasitized in 10 x 10-mile sections, state-wide survey, Delaware, 1947.

STOCKLEY—The collection of borer larvae for the recovery of parasites began in 1943 at Stockley. Table III summarizes the data for this release point. With the exception of *Bassus agilis* Cresson, a native form reared in 1945, all parasites recovered here were the tachinid fly, *L. stabulans grisescens*. During the five-year period, 106 collections totalling 3,559 live borers were made. Only four of these did not include larvae attacked by this species.

The percentage of borers parasitized in the years 1943, 1944, 1945, 1946, and 1947, were 15.1, 12.3, 12.9, 28.1, and 13.8, respectively;

TABLE III  
PARASITISM OF EUROPEAN CORN BORER LARVAE BY *Lydella stabulans* *griseocens* R. D.<sup>1</sup> AT VARYING DISTANCES FROM THE STOCKLEY COLONIZATION POINT, DELAWARE, 1943 TO 1947, INCLUSIVE

ZONES AND SEGMENT NUMBERS				1943				1944				1945				1946				1947				TOTALS AND AVERAGES				
				Number of Borers		Parasites		Number of Borers		Parasites		Number of Borers		Parasites		Number of Borers		Parasites		Number of Borers		Parasites		Number of Borers		Parasites		
						No.	%			No.	%			No.	%			No.	%			No.	%			No.	%	No.
	0-1	1-3	3-5	5-7	185	50	27.0	44	11	25.0		42	7	17.0		52	17	33.0		51	11	21.6		374	96	25.7		
	2				50	4	8.0	41	4	10.0		50	14	28.0		49	27	55.0		49	6	12.2		189	51	26.9		
	3				50	13	26.0	48	7	15.0		35	3	9.0		44	13	29.5		40	12	24.5		176	35	19.8		
	4				16	4	25.0	47	11	23.0		40	10	25.0		45	6	13.0		42	12	28.6		174	30	22.4		
	5																											
	6																											
	7				50	1	2.0	24	3	12.5		46	1	2.0		29	1	3.0		51	7	13.7		150	12	8.0		
	8																											
	9																											
Total for Zone					166	22	13.25	160	25	15.6		171	28	16.4		167	47	28.1		191	37	19.4						
					47	12	25.5					41	4	10.0		28	4	14.0		56	25	44.6		125	33	26.4		
					37	9	24.0	27	2	7.0		41	8	19.5		50	27	54.0		21	2	9.5		139	39	28.1		
					39	3	8.0	50	3	6.0		43	8	10.0		48	16	33.0		54	2	3.7		195	29	14.9		
					50	3	6.0	40	1	2.0		43	4	9.0		53	12	23.0		29	3	10.3		174	20	11.5		
					50	2	4.0					31	5	16.0		48	12	25.0		22	1	4.5		121	20	16.5		
					40	2	4.0	20	2	10.0		50	4	8.0		42	12	28.5		26	7	26.9		118	23	19.5		
					50	6	12.0	52	5	10.0		43	6	14.0		55	7	13.0		36	6	16.7		186	24	12.9		
					50	0	0	46	8	17.0		28	3	11.0		47	9	19.0		47	5	10.6		168	25	14.8		
Total for Zone					372	37	9.95	244	21	8.6		320	42	13.1		371	99	26.7		291	51	17.5						
												24	1	4.0		43	13	30.0		28	4	14.3		95	18	18.9		
	27							4	0	0.0		22	3	6.0		42	11	26.0		25	4	16.0		103	18	17.5		
	28							32	1	3.0		41	6	14.0		41	9	22.0		34	2	5.9		149	18	12.1		
	29											21	1	5.0		42	14	33.0		46	7	15.2		100	22	20.2		
	30							43	4	9.0		43	8	19.0		53	18	34.0		44	4	9.1		183	34	18.6		
	31							32	1	3.0		22	0	0.0		26	16	31.0		41	8	19.5		109	22	20.2		
	32							49	4	8.0		37	5	13.5		18	13.5	18.0		47	2	4.3		131	30	15.7		
	33											22	7	14.0		48	14	29.1		37	2	5.4		102	21	20.6		
	34											51	9	17.0		48	9	19.0		45	9	20.0		136	23	16.9		
	35											53	2	6.0		43	24	56.0		46	1	2.2		173	32	18.5		
	36											34	6	14.0		55	7	13.0		36	6	16.7		186	24	12.9		
	37																											
	38																											
	39																											
	40																											
Total for Zone					213	24	11.3	244	21	8.6		320	42	13.1		371	99	26.7		291	51	17.5						
Grand Total					723	109	15.1	661	81	12.3		661	81	12.3		661	81	12.3		661	81	12.3						

<sup>1</sup>All parasites this species, unless otherwise indicated.<sup>2</sup>Includes 6 specimens of the native parasite, *Bassus agilis* Cresson.

remarkably consistent, except for 1946. A few highly parasitized collections were responsible for the high average mortality in that year. In four of the 1946 collections, more than half of the borers were killed by parasites. The two most-heavily-parasitized collections recorded during the entire period (61.5 and 56.0 per cent) were made in that year. Oddly enough, these came from the zone five to seven miles from the release point.

In Table IV, data from the Stockley area are arranged with respect to the recovery of parasites at varying distances from the release point. The average rates of parasitism over the five-year period, 1943 to 1947, inclusive, within one, one to three, three to five, and five to seven miles of the release point, were 25.7, 18.5, 15.2, and 16.2 per cent, respectively.

TABLE IV

SUMMARY OF PARASITISM OF EUROPEAN CORN BORER LARVAE BY *Lydella stabulans grisescens* R. D.<sup>1</sup> AT VARYING DISTANCES FROM THE STOCKLEY COLONIZATION POINT, DELAWARE, 1943 TO 1947, INCLUSIVE

MILES FROM COLONIZATION POINT	PERCENTAGE OF PARASITISM FOR SPECIFIED ZONES BY YEARS					AVERAGES
	1943	1944	1945	1946	1947	
1.....	27.0	25.0	17.0	33.0	21.6	25.7
1-3.....	13.25	15.6	16.4	28.1	19.4	18.5
3-5.....	9.95	8.6	13.1	26.7	17.5	15.2
5-7.....		11.3	10.9	28.7	13.8	16.2
Averages.....	16.7	15.1	14.3 <sup>2</sup>	29.1	18.1	

<sup>1</sup>All parasites this species, unless otherwise indicated.

<sup>2</sup>Includes 6 specimens of the native parasite, *Bassus agilis* Cresson.

Not only was the average for the period higher within one mile of the release point, but each year more parasites were recovered in this than in any of the outer zones.

KIRKWOOD—At Kirkwood (fig. 2), collections of approximately 50 borers were made in the central area and in each of the odd-numbered segments within the concentric circles during the years 1945 to 1947, inclusive. In addition, a collection of 185 borers was made within one mile of the Kirkwood release point in 1943. The data for these four years at this location are presented in Table V and, in Table VI, they are arranged to show rates of parasitism at varying distances from the release point. As at Stockley, *L. stabulans grisescens* was by far the dominant species. A few specimens of other introduced parasites were recovered, including one *M. gifuensis* in 1946 and four, in 1947; also, one *C. annulipes* in 1947. In addition, two specimens of *Pyraustomyia penitialis* Coq., a native form, were reared in 1946.

The number of borers parasitized each year followed the same trend observed at Stockley, with the average parasitism of all zones being 5.6, 23.3, and 14.6 per cent for the years 1945, 1946, and 1947, respectively. In 1945 and 1946, the heaviest parasitism was within one mile of the release point and diminished directly with increasing distance

TABLE V

PARASITISM OF EUROPEAN CORN BORER LARVAE BY *Lydeella stabulans* R. D.<sup>1</sup> AT VARYING DISTANCES FROM THE KIRKWOOD COLONIZATION POINT, DELAWARE, 1943 TO 1947, INCLUSIVE

ZONES AND SEGMENT NUMBERS					1943			1945			1946			1947			TOTALS AND AVERAGES		
		Parasites		Number of Borers	Number of Borers	Parasites		Number of Borers	Parasites		Number of Borers	Parasites		Number of Borers	Parasites		Number of Borers	Parasites	
0-1	1-3	3-5	5-7			No.	%		No.	%		No.	%		No.	%		No.	%
0-1	1			185	5	2.7		46	4	9.0	16	35.0	46	1	2.2	323	26	8.1	
		3		50	1	2.0	52	17	33.0	42	2.4	144	1	2.4	19	13.2			
		5		45	1	2.0	44	1	2.0	52	7.7	141	4	7.7	6	4.2			
		6		29	5	17.0	31	14	45.0	35	14.3	95	15	14.3	24	25.3			
		7		40	0	0	50	5	10.0	44	34.1	134	15	34.1	20	14.9			
		9																	
Total for Zone					164	4.3	177	37	20.9	173	14.5		25						
	11			47	0	0	43	3	7.0	46	47.8	136	22	47.8	25	18.4			
	13			49	1	2.0	53	3	6.0	51	25.5	138	13	25.5	17	11.1			
	15			47	1	2.0	48	10	21.0	54	29.8	158	19	29.8	14	10.3			
	17			50	3	6.0	49	8	16.0	42	18.5	141	7	18.5	13	11.0			
	19			47	0	0	53	15	28.0	42	11.6	143	4	11.6	5	3.8			
	21			50	0	0	51	12	23.0	47	8.5	148	1	8.5	13	8.8			
	23			47	3	13.0	46	15	32.0	30	2.6	132	2	2.6	22	16.7			
	25			39	3	8.0	34	26	48.0	51	45.1	144	23	45.1	52	38.1			
Total for Zone					376	3.7	397	89	22.4	363	21.5		78						
	27				14		41	10	24.0	54	21.5	95	13	24.1	23	24.2			
	35						47	3	6.0	46	13.0	93	6	13.0	9	9.7			
	37						52	5	10.0	46	8.7	98	4	9.2	9	9.2			
	39						50	8	16.0	42	2.4	92	1	2.4	9	9.8			
	41						23	2	9.0	30	60.0	53	18	60.0	20	37.7			
	43						50	6	12.0	54	1.9	104	1	1.9	7	6.7			
	45						49	13	26.5	49	8.2	98	4	8.2	17	17.3			
	47						54	1	2.0	51	25.5	105	13	25.5	14	13.3			
	49						42	14	33.0	52	50.0	94	26	50.0	40	42.5			
Total for Zone					408	15.2	424	62	15.2	424	20.3		86						
Grand Total					185	2.7	1028	204	19.3	1006	18.9		190						

<sup>1</sup>All parasites this species, unless otherwise indicated.  
<sup>2</sup>Includes 1 *Macrocercus sifuenensis* and 2 *Parasitomyia penitalis*.

- Includes 4 *Macrocentrus gifuensis*.
- Includes 1 *Chelonus annulipes*.



from that point. In 1947, however, this relationship was reversed, with a rate of 2.2 per cent at the release point and of 20.3 per cent in the zone five to seven miles distant.

TABLE VI

SUMMARY OF PARASITISM OF EUROPEAN CORN BORER LARVAE BY *Lydella stabulans* *griseescens* R. D.<sup>1</sup> AT VARYING DISTANCES FROM THE KIRKWOOD COLONIZATION POINT, DELAWARE, 1945 TO 1947, INCLUSIVE

MILES FROM COLONIZATION POINT	PERCENTAGE OF PARASITISM FOR SPECIFIED ZONES BY YEARS			AVERAGES
	1945	1946	1947	
1.....	9.0	35.0	2.2	15.4
1-3.....	4.3	20.9	14.5 <sup>3+4</sup>	13.2
3-5.....	3.7	22.4	21.5	15.8
5-7.....	....	15.2	20.3	17.7
Averages.....	5.6	23.3 <sup>2</sup>	14.6	

<sup>1</sup>All parasites this species, unless otherwise indicated.

<sup>2</sup>Includes 1 *Macrocentrus gifuensis* and 2 *Pyraustomyia penitalis*.

<sup>3</sup>Includes 4 *Macrocentrus gifuensis*.

<sup>4</sup>Includes 1 *Chelonus annulipes*.

TABLE VII

PERCENTAGE OF EUROPEAN CORN BORER LARVAE PARASITIZED BY *Lydella stabulans* *griseescens* R. D.<sup>1</sup> AT SEVEN RELEASE POINTS IN DELAWARE, 1945 AND 1946

LOCATION	1945			1946		
	Number of Borers	Parasites		Number of Borers	Parasites	
		Number	Per Cent		Number	Per Cent
Hockessin.....	176	7 <sup>2</sup>	4.0	201	37 <sup>4</sup>	18.4
Townsend.....	162	43	26.5	153	37 <sup>5</sup>	24.2
Dover.....	164	4	2.4	185	19	10.3
Frederica.....	151	6	4.0	179	31 <sup>6</sup>	17.3
Farmington.....	176	0	0.0	143	19 <sup>7</sup>	13.3
Milton.....	159	19 <sup>3</sup>	12.0	188	37 <sup>8</sup>	19.7
Laurel.....	163	5	3.1	195	49	25.1
Totals.....	1151	84	7.3	1244	229	18.4

<sup>1</sup>All parasites this species, unless otherwise indicated.

<sup>2</sup>Includes 3 *Macrocentrus gifuensis*.

<sup>3</sup>Includes 1 *Macrocentrus gifuensis*.

<sup>4</sup>Includes 19 *Macrocentrus gifuensis*.

<sup>5</sup>Includes 1 native parasite, *Cremastus minor*.

<sup>6</sup>Includes 1 native parasite, *Pyraustomyia penitalis*.

<sup>7</sup>Includes 1 *Macrocentrus gifuensis*.

<sup>8</sup>Includes 6 *Macrocentrus gifuensis*.

ADDITIONAL RELEASE POINTS IN THE STATE—In Table VII, data are presented on borer parasitism at seven of the nine original liberation sites (the remaining two sites are recorded under Stockley and Kirkwood). At each of these locations, an attempt was made to secure 200 larvae for processing during the years 1945 and 1946.

Most of the parasites recovered were *L. stabulans grisescens*, but *M. gifuensis* equalled this species in material from Hockessin. Also, it was present in some of the collections from each county, indicating that it has become established. One each of the native parasites, *Cremastus minor* Cush. and *P. penitalis*, were reared.

In the two-year period, only the 1945 collections from Farmington failed to yield parasites. That the parasites became established at this point was indicated by the collection for the following year, when 13.3 per cent of the borers were destroyed. In 1945, 26.5 per cent of the Townsend collection was parasitized. This was more than twice the rate obtained at any other location.

The average parasitism in 1945 for the seven areas was 7.3 per cent. The following year, there was a rise in the number of borers destroyed by parasites. At all locations, more than 10 per cent of the borers were killed.

TABLE VIII

PERCENTAGE OF EUROPEAN CORN BORER LARVAE PARASITIZED BY *Lydella stabulans grisescens* R. D., SUPPLEMENTARY COLLECTIONS AT 10-MILE INTERVALS FROM CLAYMONT TO REHOBOTH, DELAWARE, 1945

COUNTY AND COLLECTION NUMBER	NUMBER OF BORERS	PARASITES	
		Number	Per Cent
New Castle— 1.....	56	6	10.7
2.....	55	0	0
3.....	64	3	4.7
4.....	45	7	15.6
Kent — 5.....	41	0	0
6.....	54	0	0
7.....	30	0	0
Sussex — 8.....	52	4	7.7
9.....	52	2	3.8
10.....	65	3	4.6
Totals.....	514	25	4.9

SUPPLEMENTARY COLLECTIONS—*L. stabulans grisescens* was present in six of the 10 supplementary collections (Table VIII and fig. 4). The average parasitism was 4.9 per cent. One collection from New Castle County was negative for parasites, as were all those taken in Kent County. Each of the three collections from Sussex County contained parasites.

STATE-WIDE PARASITE RECOVERIES—In 1947, a survey based on 10-mile-square sections superseded the collections made in previous years at the seven parasite-colonization-sites mentioned above. The divisions of the State and the percentage of borers killed by parasites are shown in figure 5. It is believed that an adequate sample of the distribution and density of the parasite population in the State was obtained by this method.

Table IX presents the data on the extent of parasitism of borer larvae. With the exception of one specimen of *M. gifuensis* reared from the vicinity of Hockessin, all data refer to *L. stabulans grisescens*.

The average parasitism of borer larvae in the three counties was very uniform—11.2, 11.4, and 11.9 per cent, for New Castle, Kent, and Sussex, respectively. The highest rate was recorded near Bridgeville, where 32.1 per cent of the borers were destroyed.

TABLE IX

PARASITISM OF EUROPEAN CORN BORER LARVAE BY *Lydella stabulans grisescens* R.D.<sup>1</sup>  
IN 10 X 10-MILE SECTIONS, STATE-WIDE SURVEY, DELAWARE, 1947

SECTION NUMBER	NUMBER OF BORERS	PARASITES		EMPTY PUPARIA RECORDED
		Number	Per Cent	
1	51	8 <sup>2</sup>	15.7	20
2	35	1	2.9	2
3	44	9	20.5	7
4	51	2	3.9	7
5	53	5	9.4	14
6	56	6	10.7	11
7	28	3	10.7	7
8	48	7	14.6	6
New Castle Co.	366	41	11.2	74
9	35	3	8.6	12
10	41	1	2.4	6
11	38	11	28.9	19
12	51	1	2.0	8
13	47	0	0.0	2
14	47	8	17.0	6
15	53	9	17.0	7
16	47	8	17.0	22
Kent Co.	359	41	11.4	82
17	40	5	12.5	8
18	52	13	25.0	14
19	56	18	32.1	14
20	41	3	7.3	9
21	45	2	4.4	8
22	50	9	18.0	9
23	44	3	6.8	6
24	47	6	12.8	4
25	44	2	4.5	8
26	51	2	3.9	10
27	48	4	8.3	8
28	50	4	8.0	14
29	44	3	6.8	8
30	44	4	9.1	6
Sussex Co.	666	78	11.9	126
Totals	1381	160	11.5	282

<sup>1</sup>All parasites this species, unless otherwise indicated.

<sup>2</sup>Includes 1 *Macrocentrus gifuensis*.

Parasites were reared from all but one of the 30 collections. However, there is evidence that *L. stabulans grisescens* was present at that location as well. In the course of the survey, records were kept of empty *L. stabulans grisescens* puparia found in the dissected stalks. These are shown in the last column of Table IX. Empty puparia were found at all

collection points. Actually, they outnumbered the total parasites reared—282 empty puparia were found; only 160 parasites were reared from borer larvae. However, it is likely that these puparia are the residue of more than one brood and, thus, cannot be added to, or compared with, the total parasites reared from borers.

The data presented are conclusive evidence that the spread of *L. stabulans grisescens*, since its original introduction in 1941, has been state-wide in character.

During the course of these studies, no record was obtained of hyperparasites attacking *L. stabulans grisescens*.

#### SUMMARY

A total of 97,156 European corn borer parasites representing five species—*Macrocentrus gifuensis* Ashm., *Eulophus viridulus* Thoms., *Horogenes punctorius* Rom., *Lydella stabulans grisescens* R. D., and *Chelonus annulipes* Wesm.—have been liberated in Delaware during the years 1941 to 1946, inclusive.

Information on the extent of parasitism was obtained by collecting full-grown borer larvae in the fall and early winter. These collections were made in the vicinity of the parasite release points and, in 1947, at 30 locations selected systematically so as to cover the entire State. In addition, collections were made in special study-areas established about two of the colonization sites to secure data on parasite dispersal.

Of the five species of parasites released, three—*L. stabulans grisescens*, *M. gifuensis*, and *C. annulipes*—are known to have become established. *M. gifuensis* has been reared from Hockessin, Farmington, and Milton, although it was of importance only at Hockessin. *C. annulipes* was recovered from Kirkwood alone. *L. stabulans grisescens* appears to be of considerable value throughout the State in reducing the number of overwintering borers. Studies at Stockley and Kirkwood indicate that the spread of this tachinid has been outward in all directions from the point of liberation. The average rate of parasitism for all collections at Stockley ranged from 9.95 per cent in 1943 to 28.7 per cent, in 1946. Two of the collections at this location showed in excess of 55 per cent of the borers killed by this fly. The parasitism at Kirkwood also showed an increase of from 2.7 per cent borers killed in 1943, to 19.8 per cent destroyed in 1946. Likewise, collections from the remaining seven liberation sites provided an increased parasitism rate, from 7.3 per cent in 1945 to 18.4 per cent in 1946.

In the 1947 collections designed to show parasite conditions in 30 areas throughout the State, *L. stabulans grisescens* was present in all but one. The percentage of borers killed was remarkably consistent for each county—New Castle, 11.2 per cent; Kent, 11.4 per cent; and Sussex, 11.9 per cent—or an average of 11.5 per cent for the State as a whole.

Certain native parasites—*Bassus agilis* Cresson, *Cremastus minor* Cush., and *Pyraustomyia penitalis* Coq.—were reared, but in insignificant numbers.

During the course of these studies, no record was obtained of hyperparasites attacking *L. stabulans grisescens*.

# VITAMIN REQUIREMENTS OF THE COCKROACH *BLATELLA GERMANICA* (L.)<sup>1</sup>

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The nutrition of the German cockroach, *Blattella germanica* (L.), was first studied by Zabinski (1928, 1929) who observed that these insects required "vitamin B" but that they could grow fairly well on diets inadequate for vertebrates. Somewhat later McCay (1933) suggested that this species be used as an assay animal for certain "vitamin B" fractions. Semi-synthetic diets were employed by Melampy and Maynard (1937) in a general survey of the requirements of this species. Recently a method of rearing the German cockroach has been developed which enables it to be used for quantitative studies of dietary requirements (Noland *et al*, 1949). By use of this procedure, it has become possible to determine specific requirements of the cockroach for various dietary components. The present paper describes a synthetic diet on which the growth rate of *B. germanica* equals or exceeds that on the best crude diet known. By suitable variations of this diet the effects of 11 single vitamin deficiencies on the growth of *B. germanica* have been determined. Preliminary comparisons have also been made of the growth responses of *Periplaneta americana* (L.) and *Blatta orientalis* (L.) when fed a synthetic diet and a crude diet.

## MATERIALS AND METHODS

The insects used in these experiments were from four inbred strains previously described (Noland *et al*, 1949). With inbreeding these strains have tended to become more uniform in growth response. The feeding experiments with *B. germanica* were conducted in the standard wire-screened rearing tubes described previously, while the nymphs of *P. americana* and *B. orientalis* were reared in the over-size modification of the standard rearing cage (Noland *et al*, 1949). The cages were kept in the ante-room to a 37°C. incubator, where the temperature averaged about 30°C. (27-32°C. range). In early experiments the nymphs were weighed at various ages, but later they were weighed at 10, 20 and 30 days, respectively. The average age at maturity was recorded for each group. Some groups were saved after maturity for observations of their reproductive performances.

The synthetic diets were prepared in three parts and mixed as follows. The casein and salt mixture was first ground in a Wiley mill to

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pass a 100-mesh screen, then further pulverized in a ball mill for 24 hours, and the carbohydrate added. The vitamins that were common to a series of synthetic diets were weighed out and dissolved in water. Three ml. of this vitamin solution were added to 20-gram portions of the dry ingredients. Additional solutions of single vitamins were added to specific diets as needed, and the moist ration mixed in a mortar until uniform, then spread on paper to dry at room temperature. The fat and cholesterol were dissolved in 3-ml. portions of chloroform, and stirred into the dried mixtures in a mortar. The diets were spread out to dry as before, then stored in a refrigerator. The food and water in the cages were replaced weekly. For each series of synthetic diets to be tested, the day-old nymphs from one egg-sac were divided among eight groups with about five nymphs to a cage. Usually seven of the groups received different experimental diets while the remaining group received a crude diet (dog biscuits) or the best synthetic diet available.

Riboflavin was determined by a microbiological method, with *Lactobacillus casei* as the assay organism and medium IV of Sauberlich and Bauman (1946), modified by the omission of riboflavin. Each group of insects to be analyzed was weighed, then homogenized in a Potter-Elvehjem motor-driven homogenizer with 5 ml. of 0.1 N  $H_2SO_4$ . The homogenate was autoclaved at 15 pounds pressure for 15 minutes, neutralized with NaOH to pH 6.8, diluted to 25 ml. and then filtered. Varying aliquots of this sample were added to the basal medium and incubated at 37° for 72 hours, and the amount of acid produced was determined by titration. The standard curve covered the range 0 to 0.05 micrograms of riboflavin.

#### RESULTS

*Synthetic Diets I and II.*—The composition of two fairly satisfactory synthetic diets, designated as synthetic diets I and II, has been described previously (Noland *et al.*, 1949). By using these diets as standards the requirements of roaches for the various nutrients were estimated by omitting or altering the percentage composition of single ingredients.

The growth of roaches fed different carbohydrates was determined with synthetic diet I (Table I). Dextrin (coarsely ground) promoted the fastest rate of growth, with glucose, sucrose, lactose and starch following in decreasing order (Table II). In later experiments when finely-ground dextrin was fed there was a marked decrease in the rate of growth, which became no better than when starch was fed. This apparent effect of particle size suggested that the use of coarsely ground dextrin permitted a preferential selection of other components of the diets by the nymphs. Accordingly, varying amounts of an indigestible substance (*Cellu Flour*) were added to synthetic diet II (Table I). The best rate of growth was observed when the level of *Cellu Flour* was 30 per cent of the diet, added at the expense of the carbohydrate. On this diet the *Cellu Flour* effectively increased the relative concentration of protein, salts, fat and vitamins ingested.

When a diet similar to synthetic diet I was used as a standard, and the percentage of alcohol-extracted casein in the diet was varied, the growth response was found to be greatest on the diet containing 30 per cent of casein. Decreased growth rates were observed at levels of

45, 20, 15, and 10 per cent of dietary casein (Table II). The omission of cystine from synthetic diet I caused no decrease in the growth rate.

The amount of corn oil in diet I has been varied through levels 0, 1, 2, 3, 5, and 10 per cent, at the expense of the carbohydrate. A level of 3 per cent was found to be the most favorable amount tried. The cholesterol content of diet I was varied progressively from 0 to 2

TABLE I  
COMPOSITION OF SYNTHETIC DIETS

COMPONENT	SYNTHETIC DIET No.			
	I	II	III	IV
	Parts			
Glucose monohydrate ( <i>Cerelose</i> ).....	74	62	32	32
Casein ("vitamin-free").....	15	30	30	30
<i>Cellu Flour</i> <sup>1</sup> .....			30	30
Wesson's salt mixture <sup>2</sup> .....	4	4	4	4
Corn oil.....	5	3	3	3
Cholesterol.....	1	1	1	1
L-Cystine.....	0.6			
Vitamin mixture.....	0.3	0.3	0.4	0.6
	Micrograms/gram			
Choline Cl.....	1000	1000	2000	4000
Thiamine.....	12	12	12	12
Riboflavin.....	18	18	18	18
Nicotinic acid.....	100	100	100	100
Calcium pantothenate.....	40	40	40	40
Pyridoxine.....	16	16	16	16
Inositol.....	2000	2000	2000	2000
<i>p</i> -aminobenzoic acid.....	50	50	50	50
Biotin.....	0.6	0.6	0.6	0.6
Folic acid.....	5	5	5	5
Vitamin K. ( <i>Menadione</i> ).....	1	1	1	1

<sup>1</sup>Manufactured by Chicago Dietetic Supply House, Chicago, Ill.

<sup>2</sup>Wesson, L. G., *Science*, 75: 339 (1932).

per cent (Table II), with the best growth response observed when 1 per cent of the diet was cholesterol.

The salt mixture employed (Wesson, 1932) has frequently been used by others in diets for mice and rats, and appears to contain all of the mineral elements needed by higher animals. Attempts to reduce the level of this particular salt mixture from 4 per cent to 2, 1, and 0.5 per cent, respectively, in synthetic diet I resulted in a decreased rate of growth of the roaches. It is conceivable, however, that a salt mixture

compounded especially for roaches might be adequate at a level below 4 per cent.

When the level of choline in synthetic diet II was increased from 1000 to 2000  $\gamma$ /gm. the rate of growth increased somewhat. This change, combined with the inclusion of 30 per cent of *Cellu Flour* as bulk at the expense of the carbohydrate, resulted in the formulation of synthetic diet III. The composition of this diet is given in Table I.

*Synthetic diet III.*—The results of five experiments in which dog biscuits and synthetic diet III were both fed to nymphs hatching from

TABLE II

EFFECT OF DIETARY CARBOHYDRATE, PROTEIN AND CHOLESTEROL ON GROWTH AND MATURITY OF *B. germanica* FED SYNTHETIC DIET I

DIET		WEIGHT IN MG.			MATURITY IN DAYS		SURVIVAL (FRACTION)
Component	Per Cent				Aver.	Range	
<i>Carbohydrate</i>		12 days	30 days	44 days			
Glucose <sup>1</sup> .....	74 <sup>2</sup>	5	24	43	53	47-58	5/5
Sucrose.....	74	4	21	41	55	42-77	5/6
Dextrin (coarse)...	74	6	30	53	51	49-53	6/6
Starch.....	74	3	12	17	109	92-128	4/6
Lactose.....	74	4	21	31	62	58-71	5/6
<i>Protein</i>		15 days	30 days				
Casein.....	10	6	8	.....	(dead)	.....	0/7
Casein.....	15 <sup>2</sup>	7	17	.....	66	59-76	4/7
Casein.....	30	13	35	.....	45	41-52	5/7
Casein.....	45	10	29	.....	48	43-51	6/7
<i>Sterol</i>		11 days	29 days	43 days			
Cholesterol.....	0 <sup>3</sup>	4	13	21	68	57-72	4/6
Cholesterol.....	0.001	4	12	23	70	56-82	5/6
Cholesterol.....	0.01	4	13	24	70	64-73	5/6
Cholesterol.....	0.1	5	21	36	58	49-80	5/6
Cholesterol.....	1.0 <sup>2</sup>	5	22	35	57	52-64	6/6
Cholesterol.....	2.0	5	22	38	55	48-64	6/6

<sup>1</sup>Glucose monohydrate, known commercially as "Cerelese."

<sup>2</sup>Amount of component present in synthetic diet I.

<sup>3</sup>Corn oil contains some sterols which may have been sufficient to support growth at low levels of added cholesterol.

the same egg-sacs are given in Table III. In every case the growth rate of the nymphs fed synthetic diet III was greater than the growth rate of those receiving dog biscuits, although growth and maturation on the latter diet were at least as good as that recorded previously (Noland *et al.*, 1949). Furthermore the nymphs fed the synthetic diet matured sooner than corresponding groups fed dog biscuits (Table III).



In a further evaluation of the biological value of synthetic diet III, groups of adults maturing on this diet, or on variations of it that permitted equivalent growth, were saved for a period of 40 days after maturity, and their reproductive performance compared with that of roaches fed dog biscuits. In contrast to the sustained high growth rate, fertility, and vigor of roaches reared on dog biscuits for eight successive generations, the reproductive performance of the insects reared on synthetic diets was generally unsatisfactory. The egg-sacs

TABLE III

COMPARISON OF GROWTH RATE AND RATE OF MATURATION OF *B. germanica*  
FED SYNTHETIC DIET III AND DOG BISCUITS

EXPERIMENT	WEIGHT IN MG.			MATURITY IN DAYS		SURVIVAL (FRACTION)
	10 days	20 days	30 days	Aver.	Range	
	Growth on Synthetic Diet III					
A.....	.....	22	45	38	37-40	6/6
B.....	6	23	40	39	37-41	4/4
C.....	5	19	34	43	39-46	4/5
D.....	7	31	69	33	31-36	5/5
E.....	8	.....	54	35	33-39	5/5
Average....	6.5	23.8	48.4	37.6		
	Growth on Dog Biscuits <sup>1</sup>					
A.....	.....	20	36	41	40-42	5/5
B.....	6	20	48	39	39-40	3/3
C.....	5	17	32	44	42-45	3/3
D.....	6	26	51	36	32-40	3/4
E.....	7	.....	67	36	33-37	5/5
Average....	6.0	20.8	46.8	39.2		

<sup>1</sup>Friskies Brand. Manufactured by Albers Milling Co., Peoria, Illinois.

from roaches grown on the synthetic diets were often small, deformed or shriveled. Some were discolored by transverse dark bands, while others were abnormally light in color; many were eaten by the adults. Only a small proportion of the egg-sacs produced live nymphs. When hatching occurred, the number of live nymphs per egg-sac was never greater than 30, and in many cases was only 2 or 3, as compared to a normal of 40. The nymphs were often too weak to walk, and many were eaten by the adults. Furthermore, the growth rate of these nymphs was usually slower than normal. In order to test this effect quantitatively, two hatchings of these nymphs were divided among 10 cages and fed various synthetic diets. As controls, two hatchings of

TABLE IV

EFFECTS OF SINGLE VITAMIN DEFICIENCIES ON GROWTH AND MATURITY OF  
*B. germanica* FED SYNTHETIC DIET III

VITAMIN OMITTED	EXPERIMENT <sup>1</sup>	WEIGHT IN MG.			MATURITY IN DAYS		SURVIVAL (FRACTION)
		10 days	20 days	30 days	Aver.	Range	
None (Diet III).....	A	6	23	40	39	37-41	4/4
".....	A	8	22	57	39	38-41	5/5
".....	B	6	19	.....	41	40-43	5/5
".....	C <sup>2</sup>	.....	20	38	43	34-51	5/5
".....	D	5	18	39	40	39-41	5/5
".....	E	10	22	45	40	31-44	5/6
Choline Cl.....	A	4	3	Dead	.....	.....	0/5
".....	F	3	4	Dead	.....	.....	0/6
Ca Pantothenate.....	B	3	4	Dead	.....	.....	0/5
".....	D	5	16	19	Dead	.....	0/5
".....	E	4	4	4	Dead	.....	0/6
Nicotinic Acid.....	A	4	6	6	Dead	.....	0/5
".....	D	4	14	22	Dead	.....	0/5
".....	E	4	5	6	Dead	.....	0/6
Pyridoxine.....	B	5	20	.....	44	40-54	4/5
".....	D	5	18	34	53	42-63	2/6
".....	E	11	16	22	Dead	.....	0/6
Thiamine.....	A	6	12	19	64	51-78	2/5
".....	D	4	17	38	40	39-43	5/5
".....	E	6	9	20	48	.....	1/6
Riboflavin.....	B <sup>2</sup>	6	19	.....	41	38-44	5/5
".....	D	5	19	36	50	39-59	4/6
".....	E	8	15	30	49	42-54	3/6
Inositol.....	A	9	24	47	38	34-41	5/5
".....	C	.....	14	28	45	40-52	5/5
PAB.....	A	6	21	44	38	34-41	4/5
".....	C	.....	20	38	43	41-47	5/5
Menadione.....	B	5	21	.....	39	38-40	5/5
".....	C	.....	19	31	48	44-53	5/5
Biotin.....	B	5	19	.....	41	38-43	6/6
".....	D	5	18	37	40	37-42	6/6
".....	E	11	19	32	44	38-55	3/6
Folic Acid.....	B	6	25	.....	36	36-37	6/6
".....	D	5	19	36	40	35-42	6/6
".....	E	11	26	51	34	32-37	6/6

<sup>1</sup>In experiment D, nymphs three days of age were used; in all the other experiments one-day-old nymphs were used.<sup>2</sup>Groups of insects analyzed for riboflavin (Table V).

nymphs from adults reared on dog biscuits were fed the same diets. Both the growth rate and life span of the experimental groups were only about half those of the control groups. It was therefore obvious that synthetic diet III was not adequate for the roach throughout its life cycle. Nevertheless, the fact that the diet permitted rates of growth and maturation that exceeded the best hitherto observed on crude diets has made synthetic diet III very useful in determining the role of specific nutrients in the roach.

*Effect of single vitamin deficiencies.*—With synthetic diet III as a control, roaches were fed a series of diets from which each of the B-vitamins was omitted singly, and all pertinent experiments were repeated at least once. The growth and maturation of roaches on these diets are shown in Table IV. As a result of these experiments the relative effects of single vitamin deficiencies may be divided into three classes. The critical vitamins appear to be choline, pantothenic acid and nicotinic acid. When any one of these vitamins was omitted from the diet, the rate of growth was drastically reduced and none of the roaches reached maturity. Such nymphs often died within the first month of life. However, in a single series, (Table IV, experiment D), nymphs that had access to dog biscuits for 3 days after hatching and prior to the feeding of the deficient diets grew moderately well on diets lacking nicotinic acid and calcium pantothenate, and their life span was prolonged in comparison with that of nymphs fed the incomplete diets from the day of hatching. Nevertheless, the growth rate of these 3-day old nymphs was much slower than that of "litter-mates" fed other synthetic diets, and they never reached maturity (Table IV).

Three vitamins which were limiting for growth when omitted from diet III, but which did not appear to be necessary for maturity, were pyridoxine, thiamine and riboflavin. When any one of these vitamins was omitted, individual variations in growth rate and maturity were marked, the average growth rate becoming considerably less than that of nymphs fed the complete diet. Some individual insects matured at the normal rate, while others died before maturation (Table IV).

The vitamins which caused no consistent decrease in growth rate and no increase in mortality when omitted singly included inositol, PAB, menadione, biotin, and folic acid. In some series of experiments in which these vitamins were omitted, the growth rate was as good as that on the control synthetic diet. In some cases, e.g., when folic acid was omitted in experiments B and E, maturity was reached sooner than when the control diet containing this vitamin was fed.

Since the omission of a single vitamin often exerted quite variable effects upon the growth rates of different insects in the same group, the question arose whether some of the vitamins were being synthesized in the insects. This possibility was examined in the case of riboflavin, a vitamin which is critical in the diets of higher animals but which, when omitted from the diet of the German roach caused only an irregular decrease in growth rate (Table IV). Determinations were made of the riboflavin content of roaches fed dog biscuits, synthetic diet III or synthetic diet III with riboflavin omitted; newly-hatched nymphs and the "vitamin-free" casein were also analyzed. The results of these analyses are presented in Table V.

Newly-hatched nymphs from stock females fed dog biscuits were found to contain an average of 3.9  $\gamma$  per gram, or about 0.007  $\gamma$  riboflavin per insect. When reared on a "riboflavin-free" synthetic diet, the adults contained an average of 3.0  $\gamma$  per gram, or about 0.2  $\gamma$  per insect. This indicates that each insect accumulated an average of 0.2  $\gamma$  riboflavin during its life. Analysis of the casein used<sup>2</sup> showed that it contained 0.25  $\gamma$  of riboflavin per gram. Calculation shows that each insect fed the "riboflavin-free" diet would have had to ingest 0.8 grams of the casein, or about 2.9 grams of the diet to supply all the riboflavin present in their bodies at the time of analysis. This amount of diet is approxi-

TABLE V  
EFFECT OF DIET ON THE RIBOFLAVIN CONTENT OF *B. germanica*

INSECTS ANALYZED				RIBOFLAVIN CONTENT OF FRESH TISSUE	
Number	Sex	Age	Diet	$\gamma$ /gram	$\gamma$ /insect
123	(Nymphs)	1 day	Dog Biscuits	3.8	0.007
				4.1	0.007
				3.9	0.007
8 2	Females Males	54 days	Dog Biscuits	7.0	0.49
				7.2	0.50
				6.8	0.48
2	Males	90 days	Diet III	19.7	1.15
				18.8	1.10
2	Females	90 days	Diet III	12.9	1.39
				11.9	1.28
1 4	Female Males	90 days	Diet III (riboflavin omitted)	3.2	0.23
				2.8	0.20
				3.0	0.22
			Casein used in all synthetic diets	0.20 0.27 0.27	

mately 50 times the body weight of each adult insect. It is, therefore, highly probable that riboflavin had been synthesized by the roach or by microorganisms associated with it.

*Growth of other species of cockroaches on a synthetic diet.*—Since synthetic diet III had proved superior to the best crude diet available for the growth of *B. germanica*, a similar diet, synthetic diet IV (Table I) was fed to nymphs of two other common species of roaches, *Periplaneta americana* (L.) and *Blattia orientalis* (L.), for comparison with the German roach. The day-old nymphs hatching from one egg-sac were

<sup>2</sup>This casein had been extracted with alcohol and with dilute acetic acid. The content of riboflavin found is comparable with the value of 0.26  $\gamma$  riboflavin/gram for acid-washed casein reported by Cannon *et al* (1945).

divided into two groups, which were fed dog biscuits or synthetic diet IV, respectively. The nymphs in each cage were weighed at 10-day intervals. The growth curves for these nymphs are presented in Figure 1, in comparison with growth curves for *B. germanica* on the same diets. The growth rate of *B. germanica* was much faster when diet IV was fed than when a diet of dog biscuits was used. *B. orientalis* grew at least as well on the synthetic diet as on the crude diet, and *P. americana* grew considerably better on the synthetic diet.

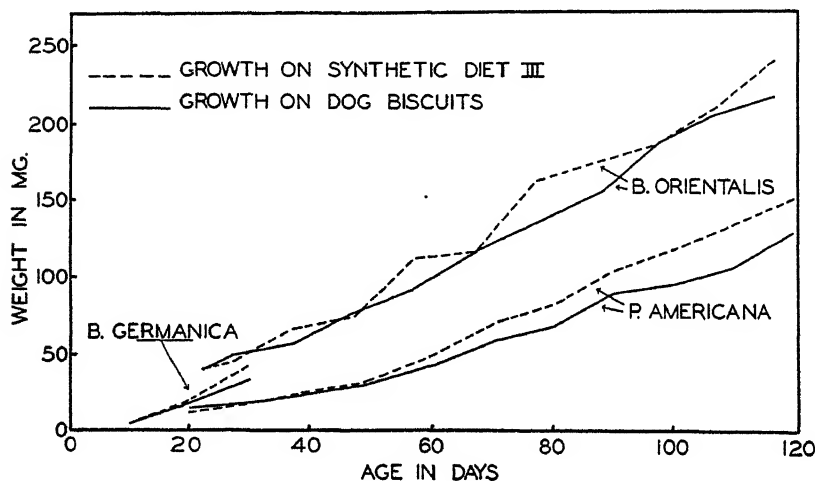


FIGURE 1. Growth of three species of cockroaches fed dog biscuits and synthetic diet III respectively.

#### DISCUSSION

The growth rates of the three species of cockroaches used in these experiments were considerably faster than those reported by others who have studied the nutrition of these species. Melampy and Maynard (1937) reported that the German roach required 42 days to attain a weight of 46 mg.; in comparison, in these experiments this weight was attained in only 30 days (Table III). Gould (1940) reported an average age at maturity of 74 days for this species, as compared with 39 days in these experiments (Table III). Using the American roach, Gier (1947) obtained a weight of 50 mg. at 100 days, as compared with 96 mg. in these experiments at the same age (Fig. 1). Recent growth data on the Oriental roach are not available for comparison.

In general, insects have not been reared as successfully on highly purified diets as on crude diets. The exceptions include the clothes moth, *Tineola bisselliella* Hum., which grew more rapidly on a highly purified diet than on the best natural diet tried (Fraenkel and Blewett, 1946a). Comparable rates of growth on purified and crude diets have been reported for the beetles *Tribolium confusum* Duv., *Ptinus tectus* Boield., *Sitodrepa panicea* L., and *Lasioderma serricorne* Fab. (Fraenkel

and Blewett, 1943). The three species of cockroaches used in the present experiments all grew faster on the purified diet than on the best crude diet tried. These species of insects are therefore added to the list of laboratory animals which may be grown successfully, and at a rapid rate of growth, under rigidly defined conditions.

The reduced ability of the cockroaches to reproduce when fed the synthetic diets could not be traced to a deficiency of any known ingredient of the diet, nor did there appear to be a good correlation between the ability of any particular synthetic diet to support growth and reproduction. This suggests the possibility that the synthetic diets may be deficient in a "reproduction factor" supplied by the dog biscuits. Grison (1947) has postulated the existence of a "fertility factor" for the potato beetle, *Leptinotarsa decemlineata* Say, which is found in fresh potato leaves but not in older leaves.

The relative essentiality of the B vitamins for the German roach is similar to, but not identical with, that of other species of insects, but it differs greatly from that of the rat, chick, and other higher animals which have been studied. Choline, the most critical vitamin for the cockroach, had previously been found by Fraenkel and Blewett (1943) to be the most essential vitamin for *Lasioderma*. However, choline did not appear to be critical for any of the other species studied by Fraenkel and Blewett, although its omission often resulted in a decreased rate of growth. In the present experiments roaches grew very poorly on the synthetic diets containing only 500 micrograms/gram of choline C1, which was the level uniformly employed by Fraenkel and Blewett in their synthetic diets for other species of insects. Furthermore, improved growth was observed with the German roach when increased levels of choline up to 4000 micrograms/gram in diet III were fed.

Pantothenic acid and nicotinic acid, which were necessary for the roach to reach maturity, were found to be essential for normal pupation of *Tineola* (Fraenkel and Blewett, 1946a), and to be necessary for the optimal growth of several other species of beetles (Fraenkel and Blewett, 1943). Pyridoxine, thiamine and riboflavin, which were necessary for good growth and survival of the German roach, but not necessary for maturity, are generally listed as being growth-promoting for insects (Trager, 1947). The finding that the omission of inositol, PAB, biotin, and vitamin K caused little or no decrease in growth rate of the cockroach is also in accord with the work of others. The fact that omission of folic acid sometimes caused an increase in the rate of growth of cockroaches has not been explained.

The indication that German roach nymphs maturing on a low-riboflavin diet accumulated more riboflavin than could be obtained merely by ingesting the diet indicates that riboflavin must have been synthesized in the insect. It is suggested that this synthesis is due to the action of microorganisms inhabiting the digestive tract. This conclusion is in accord with the observation by Busnel and Drilhon (1943) that riboflavin was produced in the gut of *Tineola* fed a riboflavin-free diet, and also with the conclusion of Fraenkel and Blewett (1946b) that the synthesis of vitamins occurs in the intestine of insects. Metcalf and Patton (1942), however, state that there is little or no synthesis of riboflavin in the American roach.

## SUMMARY

1. A basic synthetic diet is described on which three common species of cockroaches grew faster than on dog biscuits, the best crude diet tested. However, reproduction by roaches fed this synthetic diet was inferior to that of insects fed dog biscuits.

2. The requirements of *B. germanica* for the B vitamins was studied by the omission of each vitamin singly from the synthetic diet. The omission of choline, pantothenic acid and nicotinic acid resulted in extremely slow growth, and death before maturity was reached. The omission of pyridoxine, thiamine and riboflavin resulted in retarded but significant growth, and increased mortality with some insects reaching maturity. The omission of inositol, PAB, manadione (vit. K), or biotin usually had no adverse effect upon growth rate or survival, while the omission of folic acid from the diet seemed to stimulate growth somewhat.

3. German roaches reared on a synthetic diet extremely low in riboflavin accumulated more of this vitamin than was present in the diet they ingested. It is suggested that this vitamin was synthesized by intestinal microorganisms.

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# BLOOD VOLUME AND CHLORIDE NORMALITY IN ROACHES (*PERIPLANETA AMERICANA* (L.)) INJECTED WITH SODIUM CHLORIDE SOLUTIONS

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The results of the determination of blood volume in the American cockroach, *Periplaneta americana* (L.), reported in another paper (2), gave rise to the question—What changes would blood volume and blood chloride undergo if roaches were injected with different concentrations of sodium chloride solution? Partial answers to this and certain other questions are provided by experiments reported here, in which blood volume<sup>2</sup> and total chloride<sup>3</sup> in American roach nymphs were measured at different time intervals after they had been injected with different concentrations of sodium chloride solution. The results support the suggestion made previously in a study of the mode of insecticidal action of sodium metarsenite (3), that the injection of a higher concentration of sodium chloride into a roach would favor the retention of more water by the blood.

## METHODS AND RESULTS

Groups of 10 nymphs (mixed sexes) were used. All nymphs in a group were injected with the same concentration of sodium chloride dissolved in distilled water, but different groups received different concentrations. At a selected interval after injection (the interval differing with the different groups of insects) each insect was heat-fixed and its blood volume determined by the dye method (2). Each roach that had been injected with 5 N sodium chloride received 10  $\mu$  L. per gram of body weight of the dye-saline solution; all others received 20  $\mu$  L. Each group of dye-injected roaches then was divided into two subgroups of 5 each (or 4 in cases where a roach showed hemorrhage and was discarded). Blood samples from each member of a subgroup were pooled and titrated for chloride, as described elsewhere (2). Thus, for each group of 10 insects, 10 individual blood-volume determinations and two chloride titrations of pooled blood were made at the proper time interval after injection.

The concentrations of sodium chloride injected ranged from zero (distilled water) to 5 N. Distilled water was injected in only one group

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<sup>2</sup>In this paper, unless otherwise specified, blood volume will refer to the number of  $\mu$  L. of blood in an insect and blood volume percent will refer to blood volume in  $\mu$  L. divided by body weight in milligrams. One  $\mu$  L. equals 0.000001 liter.

<sup>3</sup>The chloride normalities referred to in this paper were measured by an adaptation of the titration method of Mohr (2).



TABLE I  
BLOOD-VOLUME PERCENT AND BLOOD-CHLORIDE NORMALITY OF AMERICAN ROACHES AT VARIOUS TIMES AFTER  
INJECTION WITH DIFFERENT CONCENTRATIONS OF SODIUM CHLORIDE

CONCENTRATION OF NaCl	0 MINUTES		30 MINUTES		60 MINUTES		120 MINUTES		240 MINUTES		360 MINUTES		ca. 1400 MINUTES	
	Blood- volume percent <sup>1</sup>	Chlo- ride <sup>1</sup>	Blood- volume percent	Chlo- ride	Blood- volume percent	Chlo- ride	Blood- volume percent	Chlo- ride	Blood- volume percent	Chlo- ride	Blood- volume percent	Chlo- ride	Blood- volume percent	Chlo- ride
10.00	21.5	0.562	46.3	0.301	36.4	0.289	39.2	0.276	41.2	0.305	36.6	0.283	31.8	0.199
8.00	21.5	.477	38.0	.277	40.0	.262	40.0	.274	36.6	.287	36.6	0.283	30.1	.192
6.00	21.5	.392	39.8	.254	38.8	.231	39.3	.242	35.6	.262	36.0	.260	27.4	.203
5.00	20.5	.372	39.4	.253	34.4	.196	39.2	.197	31.7	.224	36.0	.255	26.0	.175
4.00	20.5	.320	37.1	.223	34.4	.196	39.2	.197	31.0	.210	33.2	.220	21.9	.177
3.00	20.5	.278	35.6	.209	32.2	.213	36.8	.220	33.8	.211	33.5	.204	31.8	0.199
2.00	20.5	.231	29.4	.211	32.0	.203	28.7	.211	25.3	.229	28.2	.203	30.1	.192
1.00	20.5	.187	27.0	.183	35.8	.204	28.3	.202	23.4	.178	24.6	.196	27.4	.203
.50	20.5	.165	22.2	.161	21.9	.173	20.7	.158	22.3	.170	22.1	.168	26.0	.175
.25	20.5	.154	22.2	.....	.....	.....	20.7	.....	.....	.....	.....	.....	21.9	.177
.00	23.5	.127	23.7	.139	.....	.....	20.0	.137	.....	.....	.....	.....	.....	.....

<sup>1</sup>Calculated.

(in which blood volume and chloride were measured 30 minutes after injection), each roach receiving 40  $\mu$  L. per gram of body weight. In five groups receiving concentrations of sodium chloride between zero and 5 N, each roach was injected with 10  $\mu$  L. per gram of body weight. In three other groups receiving 3 N, 4 N, and 5 N sodium chloride, each roach was injected with 20  $\mu$  L. per gram of body weight. In the analysis of data that follows, after certain corrections are made on the basis of the 20  $\mu$  L. actually injected, these three groups are treated as though they had been injected with 10  $\mu$  L. per gram of body weight of 6 N, 8 N, and 10 N sodium chloride, and these last values are referred to subsequently in text, table, and figures. These three groups were treated in this way to extend the sodium chloride injections beyond the limit represented by the solubility of sodium chloride in water (ca. 7 N).

To obtain an average value for the blood-volume per cent of a group of eight or ten roaches at a given time after the injection of a given concentration of sodium chloride, the arithmetic mean of the individual determinations made with the dye method was calculated. The corresponding value for chloride was the arithmetic mean of the two titrations made on the pooled blood samples from the two subgroups. These data are presented in Table I.

The normal uninjected roach is considered to have an average blood-volume per cent of 19.5, and an average blood-chloride normality of 0.142 (2). Since each roach was injected twice, with sodium chloride solution and with a saline solution of dye, it was necessary to adjust both values to allow for a slight artificial increase. Thus in Table I the blood-volume per cent immediately after injection is given as 21.5 when 20  $\mu$  L. per gram of body weight of sodium chloride solution was injected and as 20.5 when 10  $\mu$  L. was injected. A slight increase in the normal value for chloride was necessary because the injected dye was dissolved in a saline<sup>4</sup> having a chloride normality of 0.225. Thus, those insects previously injected with sodium chloride concentrations other than 5 N were considered to have a normal blood-chloride value raised to 0.149 N to correspond with injections of 20  $\mu$  L. per gram of body weight of dye-saline solution; and, similarly, insects previously injected with 5 N sodium chloride were considered to have a normal blood volume raised to 0.146 N to correspond with injections of 10  $\mu$  L. per gram of body weight.

The normality of chloride in the blood of an injected roach at zero time (i. e., at the instant injection is completed) may be calculated, while assuming that the injected sodium chloride solution is thoroughly mixed with the blood and that the blood has not yet been affected by any transfer of fluid between the blood and tissues. Thus, if the normality (N) and the volume (d) of the injected sodium chloride solution, and the volume (V) and the normality (N<sub>o</sub>) of the roach's blood just prior to injection are known, the chloride normality (N<sub>i</sub>) of the blood at zero time may be calculated from

$$N_i = \frac{dN + V N_o}{d + V}$$

<sup>4</sup>10.93 grams of NaCl, 1.57 grams of KCl, 0.85 gram of CaCl<sub>2</sub>, and 0.17 gram of MgCl<sub>2</sub> per liter of distilled water.

For example, the calculation of average blood normality after the injection of 10  $\mu$  L. per gram of body weight of 5 N sodium chloride into nymphs of a group having an average ratio of blood volume to body weight of 0.205 and an average blood-chloride normality of 0.146, was

$$N_1 = \frac{(5)(0.01) + (0.205)(0.146)}{0.01 + 0.205} = 0.372.$$

Values calculated in this way for zero time after the injection of the different concentrations of sodium chloride are given in Table I.

As the experiment proceeded, it became desirable to have approximate values for total water and total chloride in the normal uninjected roach. Total water was estimated by drying 20 weighed nymphs in an oven at 110°–115° C. for four days and then further desiccating them over calcium chloride to constant weight. There were 9 females and 11 males, whose weights ranged from 465 to 910 mg. and averaged 704 mg. The average total water content, expressed as per cent of body weight, with the standard error of the mean, was found to be 64.9  $\pm$  0.96. The total chloride was estimated by grinding in a mortar 3 female and 2 male nymphs together with an amount of water equal to their total weight. Each of four samples of the brei was titrated with silver nitrate (1), and the normalities were averaged. This gave an approximate value of 0.179 N.

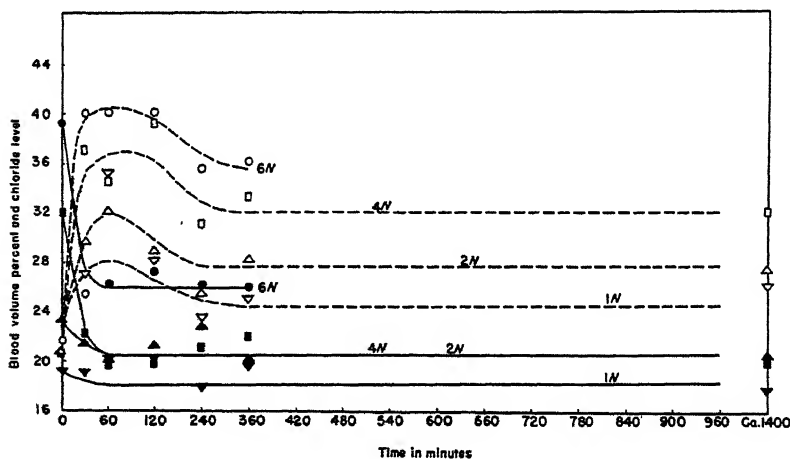


FIGURE 1. Blood-volume percent (broken lines) and chloride normality of the blood (unbroken lines) of roaches at different times after injection with different concentrations of sodium chloride. For blood-volume percent the vertical scale values are read as written; for chloride normality each value must be divided by 100. Inverted triangles, triangles, squares, and circles indicate 1 N, 2 N, 4 N, and 6 N sodium chloride, respectively.

#### ANALYSIS OF RESULTS

The data in Table I indicate that 30 minutes after the injection of a highly concentrated solution of sodium chloride into an average roach its blood-volume per cent was about twice that of the average normal

insect. This increase probably is due to an osmotic flow of water from the tissues into the blood. In general, the blood-volume per cent was still about twice the normal 60 and 120 minutes after injection, but

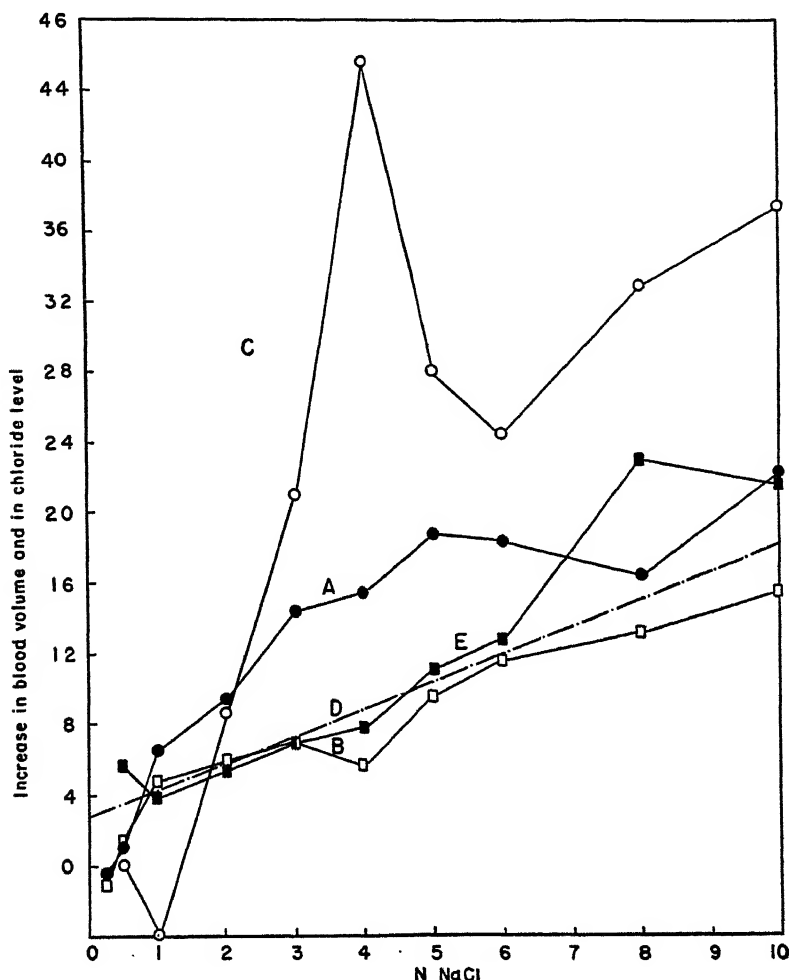


FIGURE 2. Increase in blood-volume percent and apparent blood-chloride normality above the values for the normal roach. A, Increase in blood-volume percent as determined by the dye method; B, increase in blood-chloride normality as determined by titration; C, increase in blood-volume percent as calculated from chloride increase; D, increase in blood-chloride normality as calculated from the total water content and the total chloride normality (brei) of the normal roach; E, increase in blood-chloride normality calculated on the basis of 80 percent of the blood volume as determined by the dye method. For all curves the horizontal scale is the same. For curves A and C a value on the vertical scale is the increase of blood-volume percent above the value for the normal roach; i.e., if the normal blood-volume percent were 20.5, a scale value of 16 would mean a blood-volume percent of 36.5. For curves B, D, and E a value on the vertical scale is divided by 100 and the result read as normality.

after 120 minutes it fell to a slightly lower level. Thirty minutes after injection the chloride level of the blood had fallen below the high value calculated for zero time to a level which approximately was maintained throughout the experimental period. As the concentration of injected sodium chloride was increased, blood-volume per cent attained lower and lower maximum values, but in all cases it first rose to a maximum and then fell slightly, tending to remain approximately at the lower level for about 1400 minutes. These changes are shown in figure 1.

Peters (1) summarized the findings of several authors who measured the interstitial fluids of man "by studying the concentration in the serum of injected substance to which most cells appear to be impermeable, and which are not oxidized or otherwise altered in the body." According to Peters, the results of these investigations indicate that the total volume of fluid in man is about 70 per cent of the body weight, whereas extracellular fluid (including the blood) is about 20 per cent of body weight. The blood of the roach, representing about 20 per cent of its body weight, is considered to be equivalent to the extracellular fluid in man, and the total water in the roach has been found to be 64.9 per cent of body weight. It is interesting that these values for man and for the roach are so similar.

The determination of blood volume after injection of 8 N or 10 N sodium chloride is not considered to be very reliable, for these high concentrations caused pronounced toxic effects and the circulation of the injected dye in the blood stream probably was slowed down. The data in Table I indicate, nevertheless, that the maximum blood volume increased with the concentration of injected sodium chloride up to 5 N or above, and then failed to increase much further. This is illustrated in figure 2 by curve A, which represents the increase in blood volume above the normal.

Curve A was obtained by averaging the blood volumes for 30, 60, and 120 minutes after injection, i. e., by averaging the values on the crests of curves like those shown in figure 1, except that for 10 N sodium chloride the average is for 30 and 240 minutes. Curves A, B, C, and E also were obtained by averaging values at 30, 60, and 120 minutes after injection. Comparable results were obtained by averaging the values either from 240 to about 1400 minutes or from 30 to 1400 minutes.

Curve B shows how blood chloride increases above the normal as the concentration of injected sodium chloride is increased. The curve rises rapidly at first (up to 1 N NaCl) and then more gradually, but it shows a depression localized at 4 N. Above 5 N the rate of rise of the curve becomes less. At the high concentration 8 N and 10 N sodium chloride as already mentioned, the values for blood-volume per cent may be in error because of toxic effects. But a reduced rate of blood circulation, causing an error in the blood-volume determination, would not be expected to cause an error in the chloride titration through incomplete mixing of the injected chloride with the blood, for, whereas blood volume was determined within a few minutes after the dye was injected into an insect affected by a previous injection of sodium chloride, the chloride was determined after a much longer interval (6 to 50 times as long) following the injection of the sodium chloride into the normal roach. This longer interval should have permitted a fairly complete mixing of injected chloride with the blood.

In addition to blood volumes obtained by the dye method, as discussed above, blood volumes by the pooled-blood titration method (2) were calculated for each time interval after the injection of the different concentrations of sodium chloride. Each blood volume was calculated on the basis of an average of the chloride values at 30, 60, and 120 minutes after injection. These blood volumes were plotted against the concentrations of injected sodium chloride to obtain curve C in figure 2. At concentrations up to about 2 N this curve lies near or below curve A, which represents the increase in blood-volume per cent as determined by the dye method, but soon rises to a peak at 4 N, after which it falls to lower levels but continues to remain well above curve A.

The extent to which the total water and total chloride of the normal insect are involved in the establishment of an equilibrium associated with values for chloride and blood volume after injection is not known. But, as mentioned above, the approximate volume of total water (W) in the uninjected roach was measured and an approximate value for chloride normality (T) for all tissues was obtained by titrating roach brei. By means of these approximate values and values for the normality (N) and volume (d) of sodium chloride solution injected, an approximate theoretical value for chloride normality ( $N_2$ ) in an injected insect can be calculated from the expression

$$N_2 = \frac{dN + WT}{d + W}.$$

This calculation is based upon the assumption that the total water in the uninjected insect is available to dilute injected chloride.

A theoretical chloride value, assumed to hold throughout the experimental period, was calculated in this way for each concentration of sodium chloride injected. The extents to which these values exceed the blood chloride level of the normal roach were plotted against N sodium chloride injected to form curve D in figure 2.

A comparison of this theoretical curve with curve B, which represents the rise of blood chloride above the normal as found experimentally, shows that, within experimental error, the two curves lie together up to about 3 N. Except for the drop at 4 N, curve B tends to fall further below curve D as injected sodium chloride concentration increases, particularly above 5 N. This difference between curves B and D is a measure of the amount of chloride that had become non-titratable and could be due to an excretion of some of the injected sodium chloride. If this is so, the difference between the two curves at a given injected concentration (5 N or higher) would be an approximate measure of the amount of chloride excreted, expressed as normality of sodium chloride. The close proximity of the two curves in the lower concentrations indicates that all or a large part of the total water in the roach must be available for dilution of the injected sodium chloride.

The post-injection increase of blood volume, as determined by the dye method, serves as a measure of the volume of water transferred from tissues to blood as a result of the injection of sodium chloride. But the question arises as to how much chloride leaves the blood after an injection and enters the tissues. The average blood volume of the uninjected insect was found previously to be somewhat higher when

determined by the dye method than when determined by the method of chloride titration, which itself was considered to have yielded values that are somewhat too large (2). It seems probable that the dye method gave a mean value about 20 per cent higher than it should be and so the value for blood volume ( $V$ ) by the dye method may be adjusted by multiplying it by 0.8. By the use of blood volume adjusted in this way and the chloride normality ( $N_o$ ) of the blood of the uninjected insect, a value for blood chloride normality ( $N_s$ ) after injection can be obtained from

$$N_s = \frac{dN + 0.8VN_o}{d + 0.8V},$$

where  $d$  and  $N$  have the meanings given them earlier.

By means of the average value for blood volumes at 30, 60, and 120 minutes blood-chloride normality was calculated for each concentration from the equation given above, and the increase of each value above the chloride level of normal blood was determined. These increases were plotted against the normalities of sodium chloride injected to obtain curve E in figure 2. In the lower concentrations this curve is very near curves B and D. It lies higher than curve B at 4 N and above, and higher than curve D about 6 N. If curve E were calculated on the basis of the values for blood volume given by the dye method and not corrected by the factor 0.8, it would lie near curve B at the higher and below it at the lower concentrations, an improbable situation. Unpublished data of the authors indicate that the injected sodium chloride does not begin to have a lethal effect until the concentration reaches 4 N or 5 N. If the calculations of curves D and E have been made on an admissible basis, the amount of injected chloride entering the tissues may be represented by the vertical distance of curve E above curve D, and it is of interest that the rise of curve E above curve D begins near the region of the lower lethal concentrations of injected sodium chloride.

It is not known to what extent the irregularities in the curves of figure 2 are due to experimental error. As mentioned earlier, the values for curve A at 8 N and 10 N are probably affected by a large error. These points could be considered to fall more widely about a smooth curve through the other points. If curve B is considered to be a smooth curve among all those points except the one at 4 N, which would deviate widely, then curve C (derived from B) would become correspondingly smooth but would still lie above curve A at the higher concentrations, and this would indicate a loss of chloride from the blood at these concentrations. It follows that, if a high concentration of sodium chloride were injected into a normal roach for the determination of its blood volume by the method of chloride titration, the value determined would be too high, not only because of an osmotic transfer of water from tissues to blood, but also because of a loss of chloride from the blood. Whatever may be the interpretation of the local deviations in the curves of figure 2 at 4 N and higher concentrations, the main trend of the curves is in accord with the present analysis.

Only one group of insects was injected with distilled water, and this injection resulted in negligibly small changes in blood volume and

blood chloride as determined at 30 minutes after injection. To study the effects of distilled water it would be necessary to inject much larger volumes.

#### SUMMARY

The quantitative injections of sufficiently high concentrations of sodium chloride into nymphs of the American cockroach, *Periplaneta americana* (L.), were followed by increases of blood volume that depended upon the concentration of sodium chloride injected and probably resulted from an osmotic transfer of aqueous solution from tissues to blood. Such an increase had occurred 30 minutes after injection. After a slight fall, the increased blood volume was maintained at an abnormally high level for 1400 minutes, beyond which no determinations were made. At 30 minutes after injection the chloride level of the blood had increased to a height dependent upon the concentration of sodium chloride injected and tended approximately to remain at the new height throughout the rest of the experimental period.

Evidence was obtained that, after an injection of a sufficiently high concentration of sodium chloride, the level of blood chloride was influenced by water entering the blood from the tissues, a large part of the total water in the insect probably becoming involved in the establishment of the new equilibrium. The data suggest that after the injection of the higher concentrations of sodium chloride some chloride passed from blood to tissues and some was rendered nontitratable, possibly as a result of excretion; when the injected concentration was not too high, apparently little or no blood chloride was lost to tissues or became nontitratable.

The total water content of the American roach nymphs was found to be approximately 64.9 per cent of body weight. The total apparent chloride normality for all tissues (brei) was approximately 0.179 N.

#### LITERATURE CITED

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- (2) Yeager, J. Franklin, and Sam C. Munson. Blood volume of the roach, *Periplaneta americana*, determined by several methods. Arthropoda (in press).
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#### A REPORT ON SOME MIOCENE DIPTERA FROM FLORISSANT, COLORADO, by AXEL LEONARD MELANDER. Amer. Mus. Novitates, no. 1407, pages 1-63, 71 figures. 1949.

In this paper, Professor Melander adds 62 species to the 167 species of Diptera previously recorded from the Florissant Miocene shales. Three of these are placed in new genera, but as the author remarks, "The significant point . . . is not that three genera have become extinct, but that 55 of the new species can be assigned to genera persisting today." This study will add considerably to our knowledge of generic evolution in the Diptera which, in most groups of that order, evidently took place before the Miocene. We still note, as in previous studies, evidence of a peculiar bombyliid fauna and a paucity of higher muscoids.

Comprehensive keys are given for the Sciaridae, Chironomidae, Bibionidae, Rhagionidae, Empididae, and the bombyliid genera *Alepidophora* and *Melanderella*.

—M. T. J.



## NORTH AMERICAN BEES OF THE GENUS *NOMADA*, SUBGENUS *CALLINOMADA*

(Hymenoptera: Apoidea)

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The inquiline bees of the genus *Nomada* are wasplike and generally brightly colored. They are relatively hairless, without abdominal hair bands, and with no pollen-collecting apparatus. They are commonly considered to be inquilines in the nests of bees, principally of the genus *Andrena*, although little of any concrete nature is known of their life-histories and they offer a fertile field for investigation.

The genus *Nomada* is large and the species variable, possibly in physiological response to different hosts. Following is a taxonomic study of a small group of species which appear to be closely interrelated, as well as sufficiently distinct as a group to bear a subgeneric name.

### Genus *Callinomada* Rodeck, 1945

Ent. News, 56: 181; *N. antonita* Ckll., type.

Rather small (7–9 mm.), autumnal (August to September), sexually monomorphic species. Facial quadrangle nearly equilateral, eyes only slightly converging below. Punctures of head and thorax, especially of mesonotum, fine, distinct, dense and uniform. Dorsum of prothorax sharp-edged, produced upward at sides and depressed medially, anterior face more or less concave. Scutellum never very prominent, usually low, slightly bilobed. Hair very short and sparse, nearly absent on mesonotum and sides of propodeum, often appressed on face of males. Mandibles simple, not bidentate. Antennal scape obconic, rather slender and curved. Segment 3 of antennae from about equal to, to distinctly longer than, segment 4 in front. Tegulae long-oval, narrow, often nearly triangular. Basal vein interstitial with to definitely apicad of transverse median (Figs. 1, 2). Anterior coxae sometimes with low, rounded or conical spine rudiments but never actually spined. Apex of hind tibiae in both sexes with three to five very short, stout, acute, straight spines. Abdomen distinctly and densely punctured, hair very inconspicuous. Impunctate apical margins of abdominal terga very narrow. Seventh tergum of males broad, usually very broadly rounded, entire or minutely or very shallowly emarginate. Genitalia as in Fig. 3.

*Distribution of species.*—See Fig. 4.

Distinguished from *Holonomada* by smaller size, autumnal rather than vernal season, form of prothoracic dorsum, sparsity of hair, anterior coxal spine rudiments, hind tibial bristles, form of male seventh tergum, and by the male genitalia. Distinguished from *Pachynomada* by smaller size, form of prothoracic dorsum, slenderness of male scape, hind tibial bristles, form of male seventh tergum, and by the male

genitalia. All of these differ from *Micronomada* in the absence of well-developed anterior coxal spines.

*Callinomada*, along with *Pachynomada* and *Laminomada*, has formerly been included in *Holonomada* on the basis of the entire male seventh tergum, but examination of the male genitalia shows that *Callinomada* and *Pachynomada* are probably more closely allied to *Micronomada*, on the basis of the form of the ninth male sternum (Fig. 3).

#### SYNOPSIS OF SPECIES OF SUBGENUS CALLINOMADA

##### NOMADA

###### CALLINOMADA

###### *Antonita* group

- antonita* Cockerell..... Colorado  
*snowii* Cresson..... Great Plains  
 (*omahaensis* Swenk)  
*mutans* Cockerell..... Northwest Coast  
*aquilarum* Cockerell..... Northern Great Plains  
 (*cockerelli* Graenicher)  
 (*dacotensis* Swenk)

###### *Placida* group

- placida* Cresson..... East and Midwest  
*verecunda* Cresson..... Pacific Coast

#### KEY TO MALES OF CALLINOMADA

1. Light markings white..... 2  
 Light markings yellow..... 5
2. Legs bright ferruginous and white, not at all blackened..... 3  
 Legs black, or blackish and white..... 4
3. Small light supraclypeal mark; scape white in front; wings darkened along apical margin; complete white band on first abdominal tergum; seventh tergum more narrowly rounded..... *snowii*  
 No light supraclypeal mark; scape ferruginous in front; wings hyaline; small lateral white spots on first abdominal tergum; seventh tergum broad, rounded-truncate..... *antonita*
4. Large pleural mark and peripheral fragments; scape white in front; lateral facemarks to level of antennal sockets, and separated supraclypeal mark; complete band on first abdominal tergum..... *mutans*  
 No light pleural marks, scape dark in front; facemarks practically limited to malar space; first abdominal tergum all black..... *aquilarum*
5. No light markings on first abdominal tergum, bands on terga 2 and 3 interrupted; no complete dark annulus around hind tibiae..... *placida*  
 First abdominal tergum usually with a complete or fragmentary yellow band; bands on terga 2 and 3 complete; a median black annulus completely around hind tibiae..... *verecunda*

#### KEY TO FEMALES OF CALLINOMADA

(Female of *antonita* unknown.)

1. Light markings white..... 2  
 Light markings yellow..... 4
2. Legs bright ferruginous and white, not at all blackened..... *snowii*  
 Legs black or blackish, marked with white or with yellowish-ferruginous..... 3
3. Usually extensive white mesopleural marks; a white band on first abdominal tergum..... *mutans*  
 No light mesopleural marks; no light band on first abdominal tergum,..... *aquilarum*
4. No light markings on first abdominal tergum; bands on terga 2 and 3 interrupted; no complete median black annulus around hind tibiae..... *placida*  
 First abdominal tergum usually with a complete or fragmentary yellow band; bands on terga 2 and 3 complete; a median black annulus completely around hind tibiae..... *verecunda*

**Nomada (Callinomada) antonita** Cockerell

*Nomada antonita* Cockerell, Canad. Ent., 41: 35-6, 1909, male, Colorado.

*Male*.—Length 7-8 mm. Head and thorax black marked with snowy white as follows: mandibles except tips; labrum; postmandibular area;

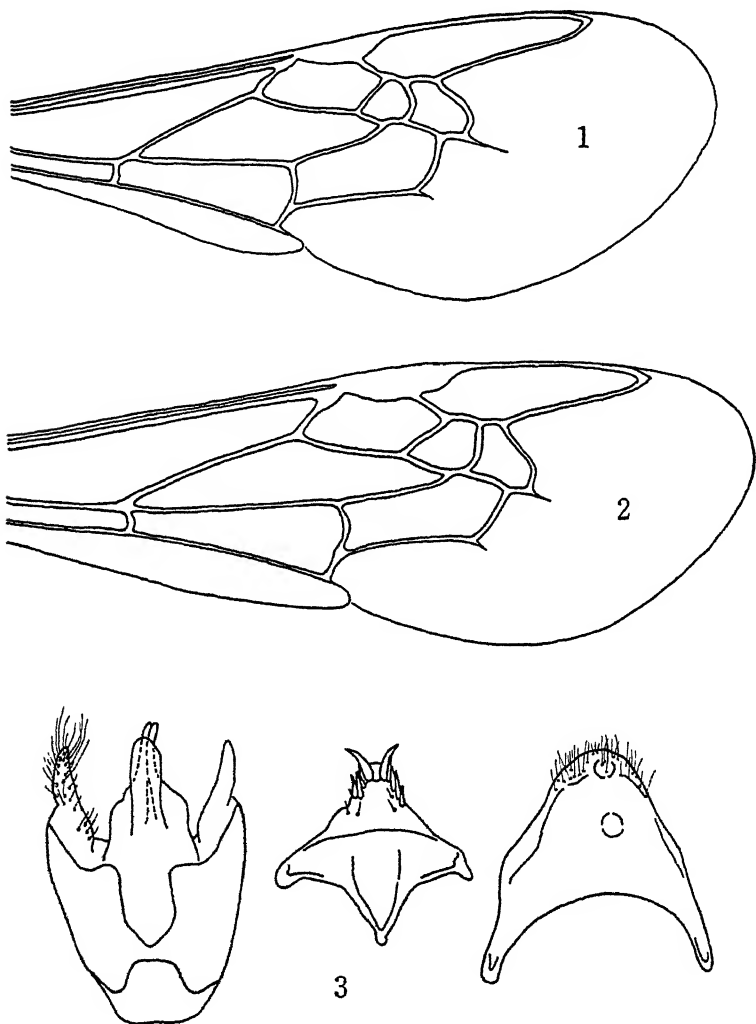


FIG. 1. Fore wing of *Nomada verecunda* (female, Oregon) showing basal vein far apicad of transverse median vein.

FIG. 2. Fore wing of *Nomada aquilarum* (male, Wisconsin) showing basal vein interstitial with transverse median vein. (Figs. 1 and 2 illustrate the approximate extremes in the relation of the basal and transverse median veins in *Callinomada*.)

FIG. 3. Genitalia (left); ninth sternum (center), and eighth sternum (right) of male of *Nomada antonita*, representing the subgenus *Callinomada*.

clypeus; lateral facemarks up the supraclypeal suture to tentorial pits, emarginate opposite the antennal sockets, thence abruptly to the orbit and continuing upward in an irregular suffused line nearly to top of eye; may be small spot at summit of eye; posterior orbits under eye and upward three-fourths of distance to top of eye; dorsum of prothorax; tubercles; a large vertical anterior pleural mark continued upward around tubercles to a point at tegulae; entire scutellum; postscutellum.

Antennal scape brown-ferruginous, strongly obconical. Flagellum ferruginous in front (segment 3 brighter), darkened behind. Segment 3 from equal to longer than 4; segment 7 broader than long. Tegulae white except for the narrow transparent rim. Wings clear, not at all darkened. Basal vein slightly apicad of transverse median.

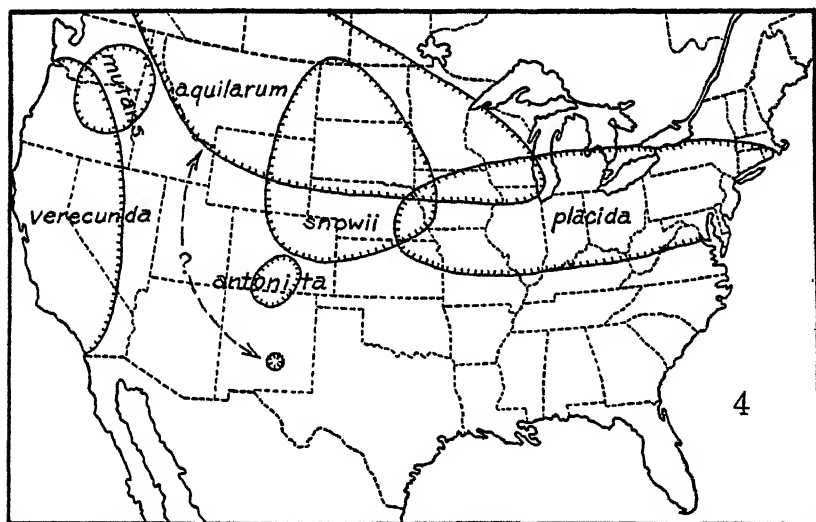


FIG. 4. Approximate known distributions of species of the genus *Nomada*, subgenus *Callinomada*.

Legs bright ferruginous with white marks as follows: on middle and hind coxae outside; apex of all femora outside and a line beneath fore and middle femora on apical half; anterior tibiae with a line down outside, second nearly all white outside, posterior with subconnected apical and basal marks outside.

Abdomen broadly oval, black, with tiny white spots far laterad on first abdominal tergum, connected by a ferruginous band. Terga 2 to 6 with complete white bands, narrowed to about one-third its lateral breadth on tergum 2. Venter of abdomen with a median subapical white spot or none on first sternum, complete broad white bands on remainder. Seventh tergum ferruginous, or white on sides, tapering, truncate-rounded at apex, and entire.

*Female*.—Unknown.

*Specimens examined*.—COLORADO: Male type (U. S. N. M. 29473), Antonito, August 5, 1900 (both right wings missing and the left front leg attached to the label); 1 male, "Colorado, 1930" (believed to be from San Luis Valley), H. G. Rodeck.

The two specimens listed are all that are known and furnish an inadequate picture of the morphology and distribution of the species.

### **Nomada (Callinomada) snowii Cresson**

*Nomada snowii* Cresson, Trans. Amer. Ent. Soc., 7: 75, 1878; female, Colorado; male, Colorado.

*Nomada (Micronomada) snowii* Cockerell, Proc. Acad. Nat. Sci. Philadelphia, 55: 608-9, 1903; female keyed from Cresson's description.

*Nomada snowii* Cockerell, Colorado Agr. Exp. Sta. Bull. 94: 72, 1905; male and female included in key.

*Nomada (Holonomada) snowii* Swenk, Univ. Nebraska Studies, 12: 85, 1913; female, South Dakota; female, North Dakota.

*Nomada (Holonomada) omahaensis* Swenk, Univ. Nebraska Studies, 15: 171, 1915; males, Nebraska.

*Male*.—7-9 mm., rather stout. Head and thorax black with white marks as follows: more or less on base of mandibles; labrum; more or less of clypeus; lateral facemarks from malar space broadly margining clypeus to tentorial pits or beyond, thence obliquely toward eye to continue up anterior orbits narrowly to level of antennal sockets or above; line under eye and up posterior orbits from half to three-fourths distance to top of eye; dorsum of prothorax; tubercles; large anterior mesopleural spot bordering tubercle above and continuing narrowly to posterior of pleura more or less suffused and interrupted by ferruginous; often spots on sterna before middle coxae; scutellum; more or less on post-scutellum.

Antennal scape stout, obconic, ferruginous, white in front, may be darkened behind. Flagellum ferruginous, more or less darkened behind, segment 3 brighter than rest. Segment 3 somewhat longer than 4; segment 7 broader than long. Tegulae sparsely punctured and shining, white except narrow rim. Wings nearly clear or slightly and uniformly tinted, a darker area near apex. Basal vein about meeting transverse median.

Legs ferruginous marked with white, more or less darkened behind femora. White marks on legs as follows: apex of all coxae outside; line beneath anterior femora (sometimes middle also) and spot at apex of all femora above; base and apex of all tibiae outside, connected on front pair; all basitarsi outside.

Abdomen black and white. Complete (or narrowly interrupted) white bands on terga 1 to 6, enclosing small sublateral dark spots on 1, broadly narrowed medially on 1 to 4, almost entire tergum on 5 and 6. Venter of abdomen black, at most a light suffusion on sternum 1. Complete or interrupted bands on sterna 2 to 6. Seventh abdominal tergum dark fuscous, tapering, rounded-entire at apex, often with white marks on lateral pleural surfaces.

*Female*.—Length about 8 mm. Head and thorax black, white and ferruginous. White marks on head and thorax as follows: spot or all of base of mandible; often basal border of labrum; more or less of clypeus; malar space and lateral facemarks bordering clypeus and

lower supraclypeus, thence diagonally upward to meet anterior orbit at about level of top of antennal sockets; posterior orbits to top of eye; dorsum of prothorax; tubercles; large vertical anterior pleural spot bordering tubercles at top; entire scutellum; postscutellum. Ferruginous markings on head and thorax as follows: most of mandible; more or less of labrum and clypeus; supraclypeus; anterior orbits from facemarks over top of eye to postorbital white; all of mesopleurae and sterna except upper margins, more or less of sides and rear of propodeum, sometimes with suffused spots on triangular enclosure.

Antennal scape short, stout, curved, ferruginous. Flagellum ferruginous in front, segment 3 brighter; flagellum darkened behind except segment 3. Segment 3 hardly longer than 4; segment 7 about as broad as long. Tegulae white except for narrow ferruginous rim. Wings rather uniformly darkened; a clearer area beyond the third cubital cell. Basal vein slightly apicad of transverse median.

Legs bright ferruginous marked with white as follows: on all coxae outside; may be a line beneath apical half of fore and middle femora; on outside apex of all femora; all tibiae at apex and base outside.

Abdomen broad oval, ferruginous at base, black and white beyond. White abdominal marks as follows: small, lateral subapical spots on the ferruginous first tergum, at times with small black spots just anterior to them; second tergum with a broad band broadly narrowed to about one-third its lateral breadth by an anterior invasion of black; third tergum similar but narrower laterally; fourth and fifth terga with white bands nearly covering the segment. Venter of abdomen ferruginous and white. White band on second sternum sublaterally emarginate from the front and perhaps narrowly interrupted medially; similar on third but continuous; a straight complete band on fourth; the apical margin of fifth sternum.

*Specimens examined*.—COLORADO: Lectotype female (Phila. Acad. Nat. Sci. No. 2597), "Col. Snow"; female, Boulder, Aug. 18, 1929, W. W. Greulich. NEBRASKA: Male type of *omahaensis* (University of Nebraska), Omaha, Aug. 29, 1914, on *Solidago canadensis*, L. T. Williams. NORTH DAKOTA: Male, Williston, Aug. 9, 1915, on *Grindelia squarrosa*, O. A. Stevens.

I have not examined the male described with the type female by Cresson, which presumably is in the Philadelphia Academy collection, from "Colorado, Morrison." Its markings are described as yellow. A paratype of *omahaensis* which I examined at the University of Nebraska has the legs much darkened behind and a nearly black "annulus" around the hind tibiae much like that of *mutans*.

### ***Nomada (Callinomada) mutans* Cockerell**

*Nomada (Holonomada) mutans* Cockerell, Psyche, 17: 91-2, 98, 1910, females, Washington.

*Male* (Allotype by present designation).—Length about 7 mm. Head and thorax black with white marks as follows: mandibles except tips; labrum; clypeus, separated from white of supraclypeus and lateral facemarks down to tentorial pits; supraclypeal spot; lateral facemarks, including malar space, from tentorial pits diagonally toward orbit well below level of antennal sockets, thence a narrow line upward along orbit

to level of antennal sockets; postmandibular area and fragmentary line half way up posterior orbits; dorsum of prothorax; tubercles; divided antero-posterior pleural mark and a curved mark below and behind tubercles; scutellum; sternal spots antero-mediad of middle and hind coxae.

Antennal scape obconic, curved, white in front, dark ferruginous behind. Antennal segment 3 yellowish-ferruginous in front, rest of flagellum darker ferruginous in front, still more darkened behind. Segment 3 rather slender, about one-fourth longer than 4; segment 7 broader than long. Tegulae white except narrow rim and central mark. Wings only slightly darkened on apical margin. Basal vein slightly apicad of transverse median vein.

Legs blackish, anterior pair ferruginous in front. Creamy white marks on legs as follows: all coxae outside; apices of all femora on top, beneath anterior and middle pair, hind pair all around; whole outside of anterior tibiae; apex and base connected by a line outside of middle tibiae; apex and base with blackish zone between on hind tibiae; all basitarsi.

Abdomen robust, black and white. Terga 2 to 6 punctured to the edge. White marks on abdomen as follows: complete bands on terga 1 to 6, notched medially in front on tergum 1 and enclosing small dark spots sublaterally; on tergum 2 gradually narrowed nearly one-half medially; narrowed medially on 3; subuniform on 4 and 5 but slightly emarginate sublaterally from the front; tergum 6 nearly all white. Venter of abdomen very dark blackish-ferruginous, distinctly punctured. White bands on sterna 2 to 5, enclosing sublateral dark spots on 2 and 3, emarginate sublaterally from the front on 4 and 5. Seventh tergum black, somewhat broad, rounded-entire at apex.

*Allotype*, male, Yakima, WASHINGTON, no other data, from R. D. Shenefelt, State College of Washington, Pullman.

*Female*.— $6\frac{1}{2}$ –8 mm. Head and thorax black with white marks as follows: mandibles except tips; labrum more or less; clypeus except upper margin down to tentorial pits; lateral facemarks irregularly upward around antennae from tentorial pits to end in a narrow blunt point, distinctly separated from eye, about three-fourths or more up anterior orbit; under eye and up posterior orbits three-fourths or more to top of eye; dorsum of prothorax; tubercles; low anterior and posterior pleural spots, often connected, and a lunate mark below and behind tubercles; more or less of scutellum; postscutellum more or less; spots antero-mediad of middle and hind coxae. Labrum with a reddish median denticle apically.

Antennal scape stout, more or less yellowish in front, ferruginous or dark behind. Flagellum ferruginous, somewhat brighter in front. Segment 3 of antennae about a third longer than 4; segment 7 about as broad as long. Tegulae white except rim. Wings uniformly very slightly darkened, a little more so at apex. Basal vein distinctly apicad of transverse median.

Legs dark ferruginous or blackish, anterior pair lighter in front, marked with white as follows: spots on all coxae; lower edge of front and middle femora near apex and extreme apex of all femora above; base and apex of all tibiae outside, often connected by a line on anterior pair; line on middle and hind basitarsi.

Abdomen black with white complete bands on all terga, enclosing small sublateral dark spots on tergum 1, narrowed to one-half lateral breadth on tergum 2, narrowed medially on 3, sublaterally emarginate from the front on 4, the fifth often nearly all white but with broad sublateral emarginations from the front. Venter of abdomen dark ferruginous with white bands on sterna 2 to 5, enclosing sublateral dark spots on 2 and 3, emarginate sublaterally from the front on 3, 4, and 5, or sometimes all sterna except first with separated lateral marks, variously emarginated.

*Variation*.—Examination of Cockerell's female type shows that the basal vein is actually apicad of the transverse median vein, rather than basad as given in his description, which is in accord with the usual condition in *Callinomada*. Cockerell's *var. a* with black postscutellum, and emarginations rather than enclosed spots on the first abdominal tergum, and his *var. b*, which is very small, with restricted facemarks, two-spotted scutellum, black postscutellum, and emarginate bands on abdominal terga 4 and 5, are both well within the range of variation to be expected. The smaller specimens (resulting from small host?) tend to show greater restriction of the white markings and less blackness of the dark areas, tending toward ferruginous.

*Specimens examined*.—OREGON: Female, Antelope Mt., Harney Co., 6500 feet elevation, Aug. 14, 1931, D. K. Frewing. WASHINGTON: Female type (U. S. N. M. 13192), 2 female paratypes (*vars. a* and *b*), Pullman, Aug. 9, 1908, W. M. Mann; male allotype, Yakima.

### *Nomada* (*Callinomada*) *aquilarum* Cockerell

*Nomada aquilarum* Cockerell, Ann. Mag. Nat. Hist., (7) 12: 208-9, 1903, male, New Mexico.

*Nomada aquilarum* Cockerell, Colorado Agr. Exp. Sta. Bull. 94: 74, 1905, in key.

*Nomada cockerelli* Graenicher, Bull. Publ. Mus. City Milwaukee, 1 (art. 3): 240, 1911, male, Wisconsin.

*Nomada* (*Holonomada*) *aquilarum* Swenk, Univ. Nebraska Studies, 12: 86-8, 1913; male, North Dakota; female, North Dakota.

*Nomada* (*Holonomada*) *dacotensis* Swenk, Univ. Nebraska Studies, 12: 88-9, 1913; females, North Dakota.

*Male*.—7-8 mm. Head and thorax black with white marks as follows: mandibles except tips; labrum; lower portion of clypeus; malar space and sometimes narrow lateral facemarks usually not extending as high as antennal sockets; tubercles; sometimes dorsum of prothorax; spots on scutellar apices or coalesced. Pleurae and propodeum extremely dark ferruginous, or black. Dark median denticle near apex of clypeus.

Antennal scape conical-curved, ferruginous, sometimes yellowish in front. Flagellum ferruginous, hardly darkened behind. Segment 3 slightly longer than 4 in front; segment 7 broader than long. Tegulae partially impunctate, ferruginous except usually an apical yellow spot and narrow ferruginous rim. Wings slightly darkened, nearly uniform. Basal vein interstitial or slightly basad of transverse median vein (Fig. 2).

Legs dark ferruginous or blackish (except anterior which are yellowish in front) marked with white as follows: on base and apex all tibiae



outside, sub-connected on first pair, sometimes on second; usually apex of all femora on top.

Abdomen fusiform, dark ferruginous or black, marked with white. Usually no white on first abdominal tergum which is all deep mahogany; on terga 2, 3, and 4 are more or less widely separated cuneiform marks pointed medially, rarely joined medially; a subinterrupted narrow band on 5; a complete band on tergum 6. Venter of abdomen dark ferruginous usually with arcuate sublateral white marks on sterna 2 to 4, often absent on 2, joined medially on sternum 5. Seventh tergum black, broad, rounded-truncate and entire at apex.

*Female*.—7-9 mm. Head and thorax black with ivory white marks as follows: very restricted lower lateral facemarks or none; a narrow line or none on dorsum of prothorax; tubercles; more or less of scutellum.

Antennal scape moderately slender, slightly curved, dark ferruginous with bright spot at base in front. Flagellum ferruginous in front, darkened behind, segment 3 often bright in front. Segment 3 of antennae hardly as long as 4 in front; segment 7 about as broad as long. Tegulae dark mahogany with small ivory spot near margin, punctate basally, impunctate apically. Wings uniformly slightly darkened with a clearer area near apex. Basal vein nearly interstitial to slightly basad of transverse median vein (Fig. 2).

Legs dark mahogany except anterior pair bright in front. White spots at base and apex of hind tibiae outside, or an irregular line connecting the two.

Abdomen rather flattened, fusiform, black and ivory white, so finely punctured as to leave the surface rather shiny. No ivory marks on tergum 1; on tergum 2 separated cuneate marks pointed mesad; on 3 similar but narrower marks; on 4 an irregular line, entire or interrupted medially, and emarginate sublaterally from the front; on 5 a subapical band emarginate sublaterally from the front. Venter of abdomen blackish, finely punctured. Lateral arcuate subapical lines on abdominal sterna 3 and 4, sometimes obscure on 3, occasionally fragments on 2. White marks on abdominal venter sometimes more extensive.

*Specimens examined*.—ALBERTA: Female, Lethbridge, Aug. 21, 1923, H. E. Gray; male, Beaverlodge, July 19, 1931, O. Peck (locality about 55° N. Lat!). NEW MEXICO: Male type (U. S. N. M. 13183), White Mts., South Fork Eagle Creek, about 8000 feet, Aug. 18, on *Erigeron macranthus*, C. H. T. Townsend. NORTH DAKOTA: Female allotype, Fargo, July 31, 1910, on *Lactuca pulchella*, O. A. Stevens; female type of *dacotensis* (Univ. Nebr. 2803), Fargo, Aug. 17, 1911, on *Grindelia squarrosa*, O. A. Stevens; female paratype of *dacotensis*, Fargo, Aug. 14, 1911, on *Melilotus alba*, O. A. Stevens; Female, Fargo, Aug. 25, 1917, O. A. Stevens; male, Granville, Aug. 7, 1915, on *Grindelia squarrosa*, O. A. Stevens. WISCONSIN: Male of *cockerelli*, Milwaukee, July (?) 15, 1908, S. Graenicher; male, Worden Township, Clark Co., July 27, 1919, on goldenrod, F. J. W. Schmidt. WYOMING: Male, Yellowstone Nat. Park, July 23, 1930, F. E. Lutz.

The specimen of *aquilarum* from Worden Township, Clark County, Wisconsin, 27 July 1919, is very like Cockerell's New Mexico type, except for larger size. It has fairly large light spots on the scutellar

lobes, but the type of *aquilarum*, contradicting the original description, has tiny ivory spots on the scutellar lobes. I have tried to find some basis for the separation of Cockerell's New Mexico specimen and those from Wisconsin, North Dakota, Wyoming and Alberta, but am unable to do so. They appear to be the same species, and it may be that subsequent collections will ultimately connect the two areas.

***Nomada (Callinomada) placida* Cresson**

*Nomada placida* Cresson, Proc. Ent. Soc. Philadelphia, 2: 291-2, 1863, female, male, Pennsylvania.

*Holonomada placida* Robertson, Canad. Ent., 35: 177, 1903, female, male.

*Nomada (Holonomada) placida* Swenk, Univ. Nebraska Studies, 12: 83 (key pp. 77-8), 1913.

*Nomada (Holonomada) placida* "Robertson" Viereck, Connecticut State Geol. and Nat. Hist. Surv. Bull. 22: 724-727, 1916, male, female, keys.

*Male*.—7-8 mm. Head and thorax black marked with yellow as follows: mandibles except tips; labrum; clypeus except upper margin down to tentorial pits; malar space, usually also lateral facemarks not extending higher than the level of antennal sockets; sometimes a post-orbital line not more than half-way up posterior orbits; more or less of dorsum of prothorax; tubercles; small low anterior mesopleural spot or none; scutellum; more or less of postscutellum.

Antennal scape slender, curved-obconic, ferruginous-yellowish in front, brighter at base, blackened behind. Flagellum yellowish or ferruginous in front, blackened behind. Antennal segment 3 somewhat longer than 4 in front; segment 7 about as broad as long. Tegulae sparsely punctured, yellowish-ferruginous. Fore wing uniformly slightly darkened, or more so near apical margin. Basal vein nearly interstitial or slightly apicad of transverse median vein.

Legs rather pale ferruginous, marked with yellow as follows: middle and hind coxae on outer edge; all femora at apex above and front and middle pair beneath near apex; whole outside of all tibiae but invaded medially on hind pair; all tarsi.

Abdomen dark ferruginous to black, marked with yellow. First abdominal tergum all dark; second tergum with large lateral cuneate marks which may join medially; similar on tergum 3 but narrower; on 4 a narrow subapical band, at times interrupted medially and shallowly emarginate sublaterally from the front; 5 and 6 usually with complete narrow bands. Venter of abdomen black, densely and distinctly punctured. Usually yellow sublateral spots on sternum 2 and complete bands or arcuate lateral marks on sterna 3 to 5. Seventh tergum rather narrow, black, rounded-truncate and usually entire at apex, but sometimes shallowly or minutely notched.

*Female*.—7-8 mm. Head and thorax black with yellow marks as follows: mandibles except tips; labrum; clypeus except upper margin; lateral facemarks from clypeus, widely emarginate around antennal sockets, concavely to a narrow point, suffused with ferruginous, near top of eye; sometimes a postorbital line; dorsum of prothorax; tubercles; small anterior mesopleural mark; scutellum; postscutellum. Supraclypeal mark ferruginous; sides of propodeum dark ferruginous.

Antennal scape slender, curved, ferruginous, bright at base in front, darkened behind. Flagellum bright ferruginous at base and darker

apically. Segment 3 about as long as 4; segment 7 slightly longer than broad. Tegulae punctured, ferruginous. Wings rather uniformly slightly darkened. Basal vein interstitial with transverse median vein.

Legs ferruginous, not much blackened behind. Yellow marks on hind coxae and a complete yellow line down outside of all tibiae, expanded at apex and base of hind pair.

Abdomen very dark ferruginous with yellow markings as follows: at most a suggestion on tergum 1; large cuneate lateral marks, approximated medially on tergum 2; on 3 similar but more wide separated; on 4 and 5 complete bands emarginate sublaterally from the front. Venter of abdomen ferruginous, distinctly and densely punctured, with fragments of lateral marks on sternum 3; complete band on 4.

*Specimens examined*.—DISTRICT OF COLUMBIA: Male, Washington, W. H. Ashmead. ILLINOIS: Male, Carlinville, Sept. 21, 1903, on *Aster ericoides villosus*, Charles Robertson. INDIANA: Female, Lafayette, Sept. 1930, George G. Ainslie. NEBRASKA: Female, Lincoln, September. NEW JERSEY: Female, Montclair, Sept. 4, 1931, M. A. Cazier. NEW YORK: Male, Fort Montgomery, Sept. 9, 1917, F. M. Schott. PENNSYLVANIA: Lectotype female (A. N. S. Phila. 2600), "Penn."; male, Carlisle Junction, Aug. 28, 1909, W. S. Fisher; female, Glenside, Sept. 15, 1908, G. M. Greene. VIRGINIA: Male, Minor's Hill, Falls Church, Sept. 13, 1912, C. T. Greene; male, E. Falls Church, Sept. 19, 1920, S. A. Rohwer.

### *Nomada (Callinomada) verecunda* Cresson

*Nomada verecunda* Cresson, Trans. Amer. Ent. Soc., 7: 203, 1879, female, male, Nevada.

*Nomada verecunda* Cockerell, Proc. Acad. Nat. Sci. Philadelphia, 55: 593, 1903, male in key only.

*Male*.—8-9 mm. Head and thorax black with yellow marks as follows: mandibles except tips; postmandibular area; labrum; clypeus except upper margin above tentorial pits; sometimes a separated supraclypeal mark; malar space and lateral facemarks widely emarginate around antennal sockets to anterior orbits, thence narrowly up orbits in a ferruginous-suffused line, often nearly to top of eye; sometimes a small post-mandibular area; dorsum of prothorax; tubercles; large irregular pleural mark usually antero-posteriorly bilobed or divided and anterior lobe usually with an upward extension below and behind tubercle; spots inside middle coxae; scutellum; more or less on post-scutellum.

Antennal scape obconic, curved, with irregular yellow line in front, darker behind. Flagellum ferruginous in front, dusky behind. Antennal segment 3 slightly longer than 4; segment 7 considerably broader than long. Tegulae nearly triangular, yellow except narrow margin. Fore wing slightly darkened apically. Basal vein far apicad of transverse median (Fig. 1).

Legs black or dark ferruginous marked with yellow as follows: all coxae; apical half or more of all femora in front and apical third of hind femora behind, others as in front; fore and middle tibiae with a median darkened spot behind, hind tibiae with a complete median dark zone ("annulus"), yellow basally and apically; all tarsi yellow.

Abdomen dark ferruginous marked with yellow. Complete subuniform yellow bands on abdominal terga 1 to 6. Venter with complete bands on sterna 2 to 6, often an irregular median mark on sternum 1. Seventh tergum often yellow at base, ferruginous apically, rather broad, tapering, often minutely but distinctly notched at apex which is rounded.

*Variation*.—A male from Nevada, probably one of Cresson's specimens, in the Cockerell collection, is small and very slender, has no yellow in front of scape, no mesopleural mark, and no yellow on postscutellum or anterior coxae. It possibly represents the minimum development of yellow coloration in males of the species. The mesopleural yellow is often confined to a low anterior mark, or none at all, the scutellar yellow is often restricted to two tiny, apical dots, there may be no yellow on prothoracic dorsum and the yellow of first abdominal sternum may be fragmentary or reduced to lateral spots.

It is perhaps significant that these restrictions in light coloration are exhibited by the small, slender, fragile specimens while the larger, more robust specimens, like Cresson's lectotype male, show the greatest color development. I suspect that these may be biological races, inquilinizing different host species, with consequent differences in amount, and perhaps kind of food. It is such conjectures as this which complicate (and add zest to) the taxonomy of *Nomada* and which suggest that the definitive taxonomy of the genus will depend on the accumulation of life-history data, including host relationships.

Cresson's lectotype male (A. N. S. Phila. 2565) is obviously not the specimen (or one of the specimens) from which he drew up his original description of the male of *verecunda*. It appears from the description that he had before him a small (0.30–0.35 inch) specimen with restricted yellow markings, as indicated by such phrases as "face-not so broadly yellow at the sides" (as in the female), "the yellow spots on pleura reduced or entirely wanting." The lectotype is a large specimen (9 mm.) with lateral facemarks extensive, and with a large, irregular, antero-posteriorly bilobed mesopleural yellow patch, the anterior lobe of which extends upward to border the tubercle beneath and behind.

Such large robust specimens with extensive yellow markings seem to have the dorsum of the prothorax less sharply edged than the smaller specimens, although they show the laterally upward-produced dorsum and concave anterior face. Large specimens may also tend to have the basal vein more nearly meeting the transverse median, although the lectotype has it far apical of the transverse median (Fig. 1).

*Female*.—7 mm. Head and thorax black with yellow marks as follows: mandibles except tips; labrum; clypeus except upper margin above tentorial pits; sometimes a supraclypeal spot; malar space and lateral facemarks, emarginate around antennal sockets, nearly to top of eye; postmandibular area and up posterior orbits nearly to top of eye; dorsum of prothorax; tubercles; low anterior and posterior mesopleural spots sometimes joined into one large patch, and with an upward anterior extension to border the tubercle beneath and behind; spot antero-medial of middle coxae; scutellum; postscutellum.

Antennal scape slender, curved, suffused yellowish in front, darkened behind. Flagellum ferruginous in front, antennal segment 3 brighter,

slightly darkened behind. Antennal segment 3 slightly longer than 4 in front; segment 7 about as broad as long. Tegulae nearly triangular, sparsely punctured, yellow except narrow rim. Wings uniformly very slightly darkened. Basal vein from interstitial to far apicad of transverse median vein (Fig. 1).

Legs dark ferruginous marked with yellow as follows: spot on outer edge of all coxae; apices of all femora, the entire front and a line down lower edge of anterior pair; all of anterior tibiae, but a median suffused dark zone nearly around middle pair and a complete nearly black zone around hind pair separating apical and basal yellow; all tarsi yellow more or less.

Abdomen dark ferruginous with yellow marks as follows: complete bands on terga 1 to 5; subuniform and enclosing small sublateral dark spots on 1; on 2 narrowed medially to half the lateral breadth; on 3 similar but narrower; on 4 subuniform with sublateral emarginations from the front; similar on 5. Venter ferruginous with complete or incomplete irregular bands on sterna 2 to 5, variously enclosing sublateral dark spots, or emarginate from the rear, or interrupted medially or sublaterally.

*Variation.*—At first glance at the females it appears that it might be possible to separate two forms, somewhat as follows:

Large mesopleural patch with extension toward tubercle; basal vein nearly interstitial; dorsum prothorax more rounded; 6-7 spines at apex hind tibiae; size larger, more robust.....	<b>Form 1</b>
Small low mesopleural spots, basal vein definitely apicad of transverse median; dorsum prothorax sharper-edged; 4-5 spines at apex hind tibiae; size smaller, more slender.....	<b>Form 2</b>

but these distinctions are apparently not valid, as there are intermediates, as well as representatives of both forms with the same collection data.

*Specimens examined.*—CALIFORNIA: Male, San Pedro, Oct. 25, 1909, G. R. Pilate; female, near Lake Eleanor, Yosemite Nat. Park, July 29, 1930, E. C. Zimmerman. NEVADA: Male lectotype (A. N. S. Phila. 2565), "Nevada"; 2 males, "Nevada" (in Cockerell coll., probably Cresson specimens). OREGON: 4 males, female, Pole Bridge Meadow, Crater Lake Nat. Park, 5900 feet, Aug. 11, 1935, George Ferguson; 10 females, Mount Hood, 3000-6000 feet, Aug. 5, 1925, C. L. Fox; female, "W. Lava," Three Sisters, Aug. 15, 1926, H. A. Scullen; female, Sparks Lake, Deschutes Nat. Forest, 4800 feet, Aug. 21, 1937, Bolinger-Jewett; female, Elk Lake, Deschutes Nat. Forest, 4600 feet, Aug. 21, 1937, Bolinger-Jewett.

EMBRYOLOGY OF THE MILKWEED BUG, *ONCOPELTUS FASCIATUS* (HEMIPTERA), by F. H. BUTT. Cornell Univ. Agr. Exp. Station Memoir 283, 43 pages, 58 figures, 1949.

The outstanding interest of this study lies in the fact that it is only the second complete study of the embryology of a heteropteron. The work presents a good appearance, with clear illustrations, and should be of great value to students of insect embryology.—M. T. J.

# A NEW SPECIES OF CTENICERA FROM THE MID-WEST (Coleoptera, Elateridae)<sup>1</sup>

EDWARD C. BECKER,<sup>2</sup>

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In material of Elateridae from Arkansas, Kentucky, and Tennessee, there were several specimens of an interesting new species of *Ctenicera* which superficially resembles *trivittata* (Lec.) to a remarkable degree. Detailed study has brought to light several structural differences, especially in the prothorax, which separate the two forms. I am greatly indebted to Dr. Merton C. Lane for first diagnosing this species as new, and for continued assistance in this investigation.

## *Ctenicera lanei* n. sp.

*Male*.—Length 15 mm., width 5 mm. Robust, very convex; head and antennae black; pronotum black with two broad sublateral stripes very dark reddish-brown, each stripe equal to one quarter of the width of the pronotum and not attaining the hind angles or the anterior angles; elytra yellow; scutellum, sutural stripe, and each humeral stripe, black; legs and underside dark brown; surface above somewhat shiny, moderately covered with short yellowish-gray pubescence which is very sparse on the elytra.

Head one half as wide as the pronotum; coarsely, closely punctured, front very little concave; antennae reaching two segments beyond the apices of the hind angles, second segment globular, third cylindrical, one and one half times the length of the second, segments four to ten serrate, each distinctly longer than wide.

Pronotum slightly wider than long, including the posterior angles; sides nearly parallel on the posterior half, thence rounded to the front angles; disc strongly convex; posterior angles divergent, each with a strong, but not sharply defined, carina parallel to the side; punctures coarse, separated by their own diameters on the disc and approximate at the sides; narrow, median, nearly punctureless, longitudinal area extending the entire length of the pronotum.

Elytra hardly twice as long as wide; widest at the apical third; each elytron with a black sutural stripe two intervals wide at base tapering to one interval wide at one half the length of the elytron; sixth and seventh intervals and adjoining parts of the fifth and eighth intervals with an irregular black humeral stripe extending from base to apex; sides of elytra evenly rounded, tapering to a blunt apex; striae impressed, punctures sparse and moderate; intervals punctulate, transversely wrinkled, and convex; supplementary stria present on the basal four

<sup>1</sup>This paper is a joint contribution from the Department of Entomology, University of Illinois, and the Illinois Natural History Survey, Urbana, Ill.

<sup>2</sup>Laboratory Assistant, Illinois Natural History Survey, during summer, 1948.

fifths of the ninth interval of each elytron where it then converges with the tenth stria.

Genitalia as in Fig. 5.

*Female*.—Length 12 mm., width 4.5 mm. Antennae extending only two thirds the length of the pronotum; the form and proportions of the segments are similar to those of the male except segments nine and ten are about as wide as long. The narrow median longitudinal area of the pronotum is punctured on the middle third, and free of punctures on the basal and apical thirds. The elytra are orange and the humeral stripes are more irregular. The supplementary stria extends on the basal two thirds of the ninth interval. Genitalia as in Fig. 6.

*Holotype*.—Male, Reelfoot Lake, Tennessee, March 29, 1948, L. J. Stannard; collection of the Illinois Natural History Survey.

*Allotype*.—Female, Washington County, Arkansas, January 15, 1938, University Farm, in soil in edge of small grain field, M. W. Sanderson; same collection as the holotype.

*Paratypes*.—One male, same data as the holotype; two males, Edmonton County, Kentucky, July 20, 1919, G. W. Bock.

The paratypes vary from 11.5 mm. long and 3.5 mm. wide to 15 mm. long and 5 mm. wide. With the exception of a slight difference in the supplementary elytral striae and the size, the paratype with the same data as the holotype is identical with it. On two of the paratypes the supplementary striae are very distinct and stop abruptly about the middle of the elytra. The two paratypes from Kentucky have orange elytra, and the humeral stripe is similar to that of the allotype. The antennae extend only one segment beyond the hind angles of the prothorax and the general color of the stripes is a light brown on one specimen.

This species could be easily confused with *trivittata* as the elytral and thoracic markings are almost identical. *C. lanei* is more robust, being three times as long as wide, whereas *trivittata* is three and one half times as long as wide. The most striking difference between the species is seen from the lateral aspect; the pronotum is much more convex in *lanei* and the prosternum is nearly straight, Fig. 4; in *trivittata* the pronotum is less convex and the prosternum is sinuate, Fig. 3. Also from the side the elytron of *trivittata* slopes gradually from the base to the apex, and in the new species it is nearly parallel to the abdomen for the basal two thirds and then slopes rather suddenly to the apex. From the dorsal aspect the elytra of *trivittata* narrow gradually from the base to the apex, and with *lanei* the elytra widen slightly from the base to the apical third and then narrow to the apex. The antennal segments four to ten are about as wide as long in *lanei*, Fig. 1, but are one and one half times as long as wide in *trivittata*, Fig. 2. In *trivittata* the elytron has no supplementary stria; in *lanei* there is a supplementary stria between the ninth and tenth striae. The differences in the male genitalia are slight, as shown in Figs. 5 and 7. In *lanei* the outside margin of each lateral lobe is straight or nearly so; the basal projections of the median lobe definitely converge, and the bases of the lateral lobes on the ventral side extend considerably below the base of the elongate chitinized structure lying on the median lobe; in *trivittata* the outer margin of the

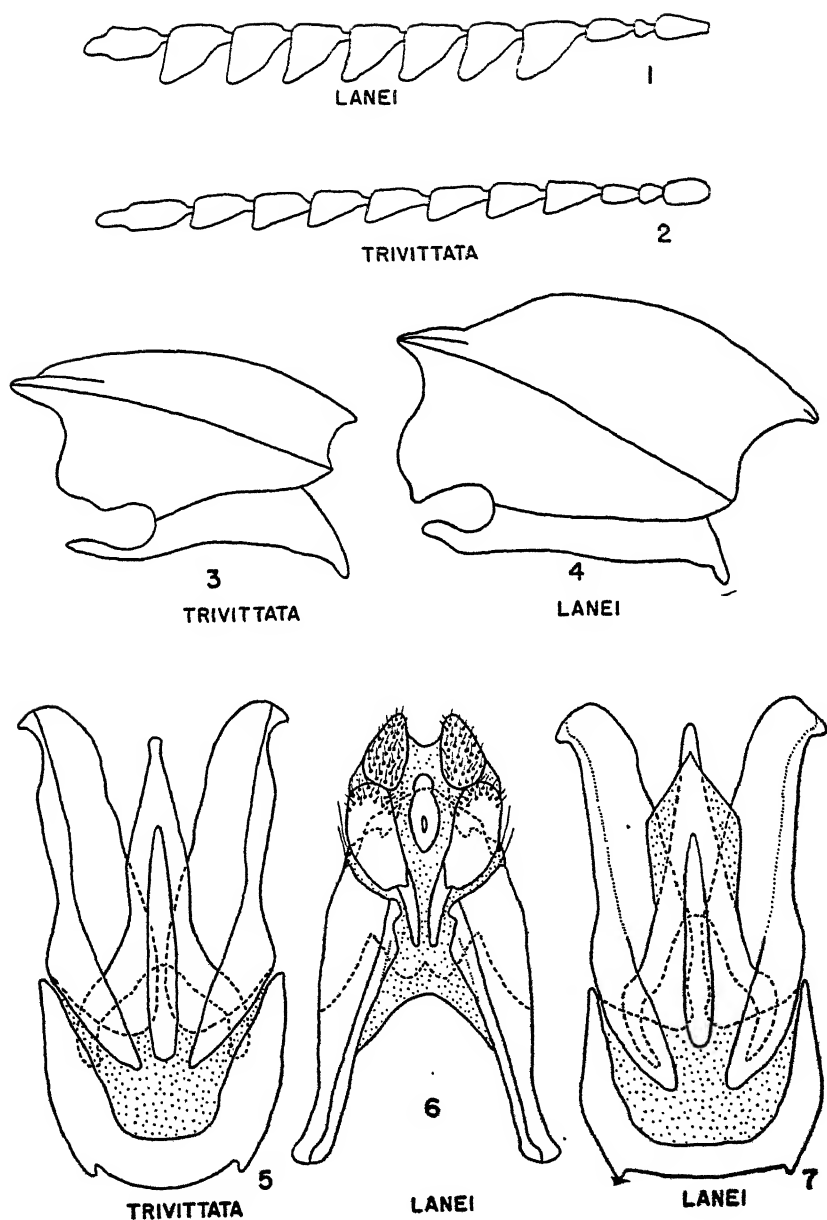


FIG. 1. *Ctenicera lanei*, male antenna. FIG. 2. *C. trivittata*, male antenna.  
FIG. 3. *C. trivittata*, prothorax, lateral aspect. FIG. 4. *C. lanei*, prothorax, lateral  
aspect. FIG. 5. *C. trivittata*, male genitalia, ventral aspect. FIG. 6. *C. lanei*,  
female genitalia, ventral aspect. FIG. 7. *C. lanei*, male genitalia, ventral aspect.



lateral lobe is curved, the ends of the base of the median lobe are not, or at most very little, converging, and the bases of the lateral lobes on the ventral side extend but very little below the base of the median structure. The female genitalia of *Ctenicera* have never been figured; illustrations of these structures are given for completeness of description rather than for comparative use.

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AN IMPORTANT NEW ENTOMOLOGICAL PERIODICAL FROM JAPAN.—In this journal (*Annals Ent. Soc. Amer.* 33: 510-512) a summary of entomological periodicals in Japan was presented, with remarks on cessation dates due to the recent war and on other details. Previously (*Ent. News* 57: 19-20) a new post-war entomological periodical had been announced.

Through the kindness of Professors Toichi Uchida and Chihisa Watanabe of the Entomological Institute, Hokkaido Imperial University, Sapporo, Japan, I have received copies of an important new Japanese entomological journal, MATSUMUSHI. It is the Japanese language companion to INSECTA MATSUMURANA, which contains papers only in European languages. The latter journal has not yet resumed publication because of unavailability of materials. Of the four editors of MATSUMUSHI, Drs. Watanabe and Hiroshi Takahashi are members of the Entomological Society of America, and Dr. Uchida is a former member. Mr. S. Hukusima is the other editor.

Volume I of MATSUMUSHI includes two numbers, dated September and December, 1946. According to the announcement in the first issue all succeeding volumes will contain four numbers. Volume II, number 1, is dated June, 1947.

Though papers in MATSUMUSHI are in Japanese, three of the four taxonomic papers in the first three issues have thorough English resumés. The remaining papers have only enough scientific names and names of entomologists to be very tantalizing. The figures, with English wording, further arouse the reader's interest but not satisfaction. The subject matter is obviously of considerable importance. Dr. Watanabe has furnished me with brief summaries of much of the content of the three issues.

Professor Emeritus Shonen Matsumura, father of Japanese entomology, in the foreword of the first issue, calls for the post-war revival of entomology in Japan and a plea for application of knowledge to aid in solving the food problem. Dr. K. Yasumatsu has papers on tree-hole rubbish fauna, Mutillidae from East China, and a new chalcid from Japan (*Dromochalcidia nigra*). Dr. C. Watanabe has papers on a revision of the world Paxylomatidae, the Japanese *Leucospis*, and the necessity for a national museum in Japan. Mr. K. Tsuneki has a paper on the nomenclature of the Japanese Chrysididae and several notes on habits of Crabronidae. T. Shirozu has a large paper on the zoogeography of Japanese butterflies. There are several papers on various aspects of economic pest insects by Hukusima, Kuwayama, Nishijima, Kato, Utida, Fukuya, Nagasawa, Moritsu, Ozawa, and Takeya. Dr. H. Takahashi gives a list of mosquitoes of Hokkaido and a translation of the reviewer's paper on *Uranotaenia* feeding (*Ent. News* 56: 32-37, 64-68). A study of diurnal activity of mosquitoes is by five authors. There are book notices of Tsuneki's "Hunting Wasps" and Watanabe's book on Japanese parasitic Hymenoptera. T. Shimizu has a notice on the new plant quarantine. Of particular interest are reports from noted Japanese entomologists who were in Japanese invaded territory or elsewhere when the war ended. Their whereabouts and safety had been uncertain at that time. MATSUMUSHI has reports from Dr. R. Takahashi back from Malaya, Dr. K. Iwata returned from Hainan Island, A. Kawada from Java, R. Yoshii from Europe, and Dr. Y. Miwa and M. Chujo from Formosa. The famous professors from Taihoku Imperial University, Shiraki and Issiki, remained in Formosa with their great collections and library.

Professor Watanabe has informed me that he is very desirous of establishing permanent exchanges of MATSUMUSHI for all other entomological periodicals. Correspondence should be addressed to Editors of Matsumushi, Entomological Institute, Hokkaido University, Sapporo, Japan.—CHARLES L. REMINGTON.

# A BIOLOGICALLY ANNOTATED LIST OF THE BUPRESTIDAE OF THE LOWER RIO GRANDE VALLEY, TEXAS<sup>1</sup>

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College Park, Maryland

During the period between January 1, 1946 and October 6, 1947, the writer collected insects regularly on weekends over much of the area generally known as the Lower Rio Grande Valley, Texas. The Buprestidae are well represented in the resulting collection and a list of the 63 species taken are here given with biological notes.

For verification of many of the identifications of the Buprestidae listed here, for much sound advice and no small measure of encouragement and general assistance, the writer is gratefully indebted to Mr. W. S. Fisher of the U. S. National Museum. Dr. J. N. Knull of the Ohio State University, has kindly read the manuscript and compared a number of specimens with types in his collection. For determinations on most of the plants referred to in this paper, the writer expresses his sincere gratitude to Mr. H. B. Parks, Botanist in Charge, S. M. Tracy, Herbarium, Agricultural and Mechanical College of Texas.

## PLANTS REFERRED TO

For brevity and general readability, the common names of the plants listed below will be used in the text.

- \*Amargosa—*Castela texana* (T. & G.) Rose (Simarubaceae)
- \*Anacua—*Ehretia anacua* (Berl.) Johnston (Boraginaceae)
- Ash—*Fraxinus* sp. (Olivaceae)
- \*Black brush—*Acacia rigidula* Benth. (Leguminosae)
- \*Brasil—*Condalia obovata* Hook. (Rhamnaceae)
- \*Capote—*Diospyros texana* Scheele (Ebenaceae)
- \*Catsclaw—*Mimosa biuncifera* Benth. (Leguminosae)
- Cedar elm—*Ulmus crassifolia* Nutt. (Ulmaceae)
- \*Ceniza—*Leucophyllum texanum* Benth. (Scrophulariaceae)
- Colima—*Xanthoxylum pterota* H. B. K. (Rutaceae)
- \*Coma—*Bumelia celastrina* H. B. K. (Bumeliaceae)
- Composites (Compositae) including:
  - Helianthus* sp. (mostly *angustifolius* L.)
  - \**Parthenium hysterophorus* L.
  - \**Helenium microcephalum* D. C.
  - \**Verbesina encelioides* (Cav.) Benth. and Hook.
- \*Coyotillo—*Karwinskia humboldtiana* (R. & S.) Zucc. (Rhamnaceae)
- Ebony—*Pithecolobium flexicaule* (Benth.) Coulter (Leguminosae)
- \*Giant opuntia—*Opuntia lindheimeri* Engelm. (Cactaceae)
- \*Granjeno—*Celtis pallida* Torr. (Ulmaceae)
- \*Guajillo—*Acacia berlandieri* Benth. (Leguminosae)
- \*Guayacan—*Porleieria angustifolia* (Engelm.) A. Gray (Zygophylliaceae)
- \*Gulf Coast guajillo—*Pithecolobium pallens* (Benth.) Cory
- Hackberry—*Celtis laevigata* Wild. (Ulmaceae)

<sup>1</sup>Scientific article No. A200, Contribution No. 2116 of the Maryland Agricultural Experiment Station (Department of Entomology).

- \*Huisache—*Acacia farnesiana* (L.) Willd. (Leguminosae)
- Huisachillo—*Acacia tortuosa* (L.) Willd. (Leguminosae)
- \**Lippia ligustrina* (Lag.) Britton (Verbenaceae)
- \*Lote—*Condalia obtusifolia* (Hook.) Weberb (Rhamnaceae)
- \**Lycium*—*Lycium Berlandieri* D. C. (Solanaceae)
- \*Mesquite—*Prosopis juliflora* (Swartz) DeCandolle (Leguminosae)
- \*Mexican olive—*Cordia boissieri* D. C. (Boraginaceae)
- \*Mimosa—*Mimosa Lindheimeri* A. Gray (Leguminosae)
- \*Myrtle croton—*Bernardia myricaefolia* (Scheele) S. Wats. (Euphorbiaceae)
- Palm—*Sabal texana* Bece. (Palmaceae)
- \*Palo verde—*Cercidium macrum* Johnston (Leguminosae)
- \**Phaulothamnus spinescens* A. Gray (Phytolaccaceae)
- \**Ptelea Baldwinii* T. & G. (Rutaceae)
- \*Retama—*Parkinsonia aculeata* L. (Leguminosae)
- \*Rock brush—*Eysenhardtia texana* Scheele (Leguminosae)
- Screw bean—*Prosopis cinerascens* A. Gray (Leguminosae)
- \*Seaside croton—*Croton punctatus* Jacq. (Euphorbiaceae)
- \*Soapberry—*Sapindus Drummondii* H. & A. (Sapindaceae)
- Tasajillo—*Opuntia leptocaulis* D. C. (Cactaceae)
- Tepehuaje—*Leucaena pulverulenta* (Schlecht) Benth. (Leguminosae)
- Texas all-thorn—*Koeberlinia spinosa* Zucc. (Koeberliniaceae)
- Tree catsclaw—*Acacia Wrightii* Benth. (Leguminosae)
- \*Vine minosa—*Mimosa malacophylla* A. Gray (Leguminosae)
- Willow—*Salix* sp. (Salicaceae)
- Yucca—*Yucca treculeana* Carr. (Liliaceae)

#### DESCRIPTIONS OF COLLECTING LOCALITIES

The distribution of the collecting localities is accurately shown on Fig. 1. For the sake of brevity, the numerical designations are used in the list. These localities represent a number of types of distinct floral associations, and a brief general description<sup>2</sup> of each of them seems pertinent.

Localities 1 through 10 are situated in the broad alluvial floodplain and delta of the Rio Grande. Practically all of the land to the north of these localities is under cultivation.

Locality 1 is a portion of the narrow strip of short penetrable brush growing on the elevated places between the salt flats and meadows close to the coast. Mesquite, granjeno, ebony, yucca and giant opuntia predominate.

Locality 2 is a palm jungle interspersed with tepehuaje, Gulf Coast guajillo, anacua, ash, and ebony as well as a great number of vines and a variety of lower story woody and herbaceous plants.

Localities 3 and 4 are moderate-sized tracts of dense, mostly impenetrable chaparral averaging 15 to 20 feet in height and composed principally of Gulf Coast guajillo, ebony, mesquite, brasil, *Phaulothamnus*, *Lippia*, coma, giant opuntia, myrtle-croton, capote, Mexican olive and tree catsclaw. During 1946 collecting at 4 was confined to an area which was being hand-cleared.

Locality 5 is a dense forest 25 to 30 feet in height composed of tepehuaje, cedar elm, hackberry and anacua, all profusely adorned with Spanish moss. Further away from the river mesquite forestland succeeds.

\*Based on determination by H. B. Parks.

<sup>2</sup>In each case the description applies only to areas in which collecting was actually carried out.

Locality 6 is a medium, mesquite forest (15 to 25 feet high) intermixed principally with lote, granjeno, giant opuntia, yucca and some blackbrush and huisachillo.

Locality 7 is a low lying government-maintained floodway which is largely covered with second growth mesquite and huisache, much of it weakened by high water table and salt.

Localities 8 and 10 are portions of an extinct and heavily silted river bed covered with a heavy stand of hackberry (25 to 40 feet high) interspersed with little underbrush as a result of pasturage. Spanish moss is common and in especially low places large willows frequently occur. Along the inland bank grows a heavy stand of anacua, ebony, elm and soapberry. This narrow strip of interesting flora grades into the heavy mesquite forest described next. A portion of 10 was being hand cleared during 1946.

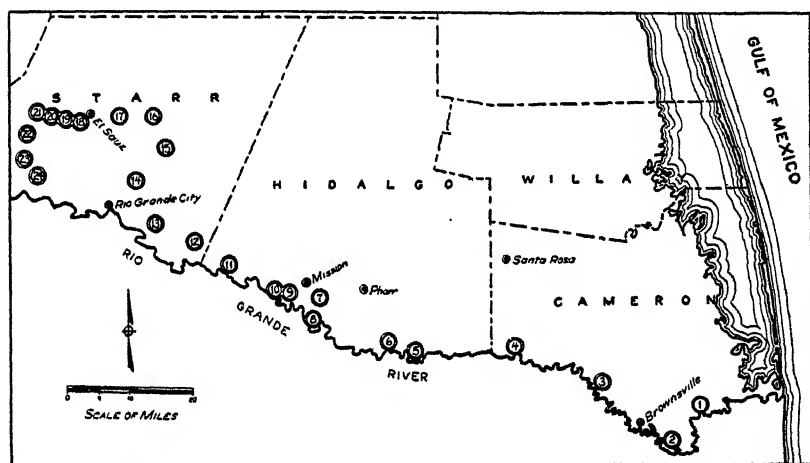


FIG. 1. Distribution of collecting localities.

Locality 9 is a heavy mesquite forest (20 to 30 feet high) intermixed with granjeno, giant opuntia, lote, colima, blackbrush, huisachillo, guajillo and coma. A large section of this area was cleared during the summer and fall of 1946.

Localities 11 through 24 are situated in the gently rolling upland region rising rather suddenly from the flood plain of the Rio Grande (considerably narrowed in this region). The soil is comparatively poor and good drainage creates semiarid conditions. As a result vegetation is stunted and sparse so that it is possible to walk almost anywhere with most vegetation within reach of net.

Localities 11 and 12 are two relatively low lying areas with mesquite, coyotillo, myrtle croton, ebony, coma, capote and colima predominating.

Locality 13 is atop one of the gravel-covered hills overlooking the Rio Grande flood plain. Its flora is composed almost exclusively of blackbrush, *Ptelea Baldwinii* and giant opuntia.

Localities 14 and 21 are exuberant growths of brush at the heads of dry land washes with coyotillo, rock brush, myrtle-croton and *Lycium Berlandieri* predominating. An extensive stand of ceniza surrounds area 14.

Localities 15, 19 and 22 are well-drained elevated areas covered largely by blackbrush, guajillo, giant opuntia and yucca together with some mesquite, granjeno, coyotillo, palo verde and lote.

Localities 16, 17, 18 and 20 are badly eroded dry-land washes supporting very little except decadent mesquite and in places the diminutive screwbean, also some granjeno and lote.

Locality 23 is a dry-land wash supporting principally mesquite, ebony, *Mimosa biuncifera* and colima.

Locality 24, is a dry hillside covered principally with blackbrush, giant opuntia, *Ptelea baldwinii*, lote, palo verde, mesquite and granjeno.

Huisache was found in abundance in all the localities described for Hidalgo and Cameron Counties. It usually occurs in pure stand in many places along the banks of the Rio Grande, along the edges of resacas and other low places that are so common throughout the broad alluvial flood plain south and east of Mission. It was usually in and around the habitat of the huisache that most of the flowering composites occurred which produced so many of the *Acmaeodera* reported here. In the uplands of Starr county, mesquite largely replaces huisache in the dry land washes which constitute the low lying areas. Just as in Hidalgo and Cameron counties, these low places when not too badly eroded, and especially when at the head of a dry land wash, supported the flowering composites on which *Acmaeodera* were collected.

#### ANNOTATED LIST OF BUPRESTIDAE COLLECTED<sup>3</sup>

1. *Polycesta velasco* Cast. 5 and 20. May 17 through June 14. Fifteen specimens (only one of these from 5) all on dead branches of decadent mesquite.

2. *Acmaeodera gibbula* Lec. 6, 12, 14, 16, 20, and 22. May 24 through July. Rather common, usually on or in flight near dead or dying branches of various shrubs, principally ceniza, mesquite and lote. Also on flowers of composites.

3. *Acmaeodera uvaldensis* Knull. 22. April 6, 1947. Two males beaten from mesquite which was in bloom and fresh in leaf.

4. *Acmaeodera flavomarginata* Gray. 7, 11, 12, 14 and Santa Rosa. September 29 through October. Common on flowers of composites, often in company with 5, 8, and 9.

5. *Acmaeodera macra* Horn. 7, 11, 12, 14 and Santa Rosa. September 29 through October. Not common on flowers of composites, usually in company with 4, 8, and 9.

6. *Acmaeodera miliaris* Horn. 6, 7, 9, 10, and 11. May 3 through July 4. Twelve specimens, all from flowers of composites.

7. *Acmaeodera flavinigrapunctata* Knull. 4, 6, 9, 10, 11 and 12. May through June. Frequent on flowers of composites, often in company with 11.

<sup>3</sup>In this list, figures in italics denote collecting localities; those in roman print refer to species numbers in the annotated list of Buprestidae.

8. *Acmaeodera rubronotata* Cast. 7, 11, 12, 14 and Santa Rosa. September 29 through October. Common on flowers of composites, usually in company with 4, 5, and 9.

9. *Acmaeodera scalaris* Mann. 2, 3, 7, 11, 12, 14 and Santa Rosa. September through October. The most common of the fall *Acmaeodera*. Usually on flowers of composites and in company with 4, 5, and 8. Also occasionally found on fresh cut huisache.

10. *Acmaeodera obtusa* Horn. 6, 13, 19, 21, and 22. April 6 through May. Common mostly on flowers of giant opuntia.

11. *Acmaeodera pulchella* (Hbst.). 2, 4, 6, 10, 11, 12, 14, 19, 21, and 22. May 24 through July 4. An aberrant record was made at Santa Rosa when a single specimen was swept from flowers of a yellow aster on September 14, 1946. This species occurs usually on flowers of composites and is probably the most abundant *Acmaeodera* of the Lower Rio Grande Valley. In Hidalgo and Cameron Counties *pulchella* frequently was found on the same flowers with 7.

12. *Acmaeodera* sp. near *cribricollis* Horn. 24. April 6, 1947. A single male specimen on foliage of *Ptelea Baldwynii*.

13. *Acmaeodera quadrivittata* Horn. 19. April 12, 1947. A single specimen on flower of a small cereus cactus.

14. *Acmaeodera hulli* Knull. 20. May 17, 1947. A single specimen on weakened granjeno. Two other specimens were observed that same day on granjeno at nearby 19.

15 & 16. *Acmaeodera tubulus* (Fab.) and *A. neglecta* Fall. A series of 60 specimens selected from many hundreds seen in the field, includes what appears to be typical *tubulus* and typical *neglecta* but in between variants seem to run together. The variations involve size, robustness, confluency of maculations, luster, punctuation, and hair and setal prominence. These *Acmaeodera* are widespread and common in occurrence, having been found at just about all localities March through May on flowers of various types, especially those of cacti and composites.

17 & 18. *Acmaeodera* spp. near *gemina* Horn. 13, 19, 22, and 24. April 6 through May 3. Rare on flowers of cacti and on guajillo.

19. *Paratyndaris olneyae crandalli* Knull. 16, 17, and 20. May 3 through August. Frequent, especially during July and August, on dead branches of decadent mesquite. Also on dead branches of Rock brush. These beetles feed freely on the bark of dead branches, and they have been observed to cut deeply into the wood of dead terminal twigs.

20. *Paratyndaris chamaeleonis* Skinner. 4, 9, 12, 14, and 16. June, July and August. Frequent on dead branches of ceniza. Also ovipositing in dead mesquite branches; and on *Lycium Berlandieri*.

21. *Hippomelas sphenica* (Lec.). 9, 15, 16, 20 and Santa Rosa. September 15 through November. Very common on mesquite, especially on decadent and fresh cut trees where brush is being cleared. Females were often seen ovipositing in dead mesquite snags. These beetles seem to feed freely on mesquite foliage as evidenced by their copious green-colored fecula. Fresh emerged specimens lack the

characteristic yellow pulverulence which seems to be a secretion accumulating with age. Evidently pulverulence, as it generally occurs among the Buprestidae, is of this nature; therefore, the variations in the definition of the pulverulent markings in this family. It is pointed out, however, that the pubescence associated with such markings is apparently unaffected by age but rather by abrasion.

22. *Psiloptera drummondi* Cast. 13, 14, 15, 22, and 23. June through November. Common, especially so in the fall and early winter on weakened coyotillo, guajillo, and blackbrush. A single specimen was collected on June 24 from Gulf Coast guajillo at 4. These beetles characteristically feed on the twigs one to two inches from their tips, usually chewing them partly off. During October and November in heavily infested areas coyotillo conspicuously shows much dead terminal foliage and chewed and broken branch tips.

23. *Psiloptera cupreopunctata* Schffr. 3, 4, 8, 9, 10, and Santa Rosa, September through November. During October and November very common on mesquite, huisache and occasionally on coma, especially where brush is being cleared. On mesquite this species has the habit of chewing the bark at the bases of leaf petioles in such a manner as to cut off the leaves. Heavily attacked trees may be almost completely defoliated. The fecula of this species is brown in color.

24. *Dicerca lurida* (Fab.). 8 and 10 May. Two specimens collected on dead willow. Also a number of dead specimens were cut from a dead willow trunk.

25. *Cinyra prosternalis* Schffr. 4. June 22 through July. Eight specimens on capote. Emergence holes indicate that this species bores in the heart and sapwood of healthy capote. Often large amounts of gum exudes from the emergence holes and other mechanical injuries on these trees.

26. *Chrysobothris lixa* Horn. 18 and 24. April 6 and April 12. Two males beaten from mesquite fresh in leaf.

27. *Chrysobothris pubilineatus* Vogt. 13. April 6 through April 17. Three specimens collected on blackbrush. About five others were missed.

28. *Chrysobothris ephedrae* Knull. 22. A single male April 6, 1947 on blackbrush. Two others were seen in company with 27 at 13 but these were missed.

29. *Chrysobothris prosopidis* Fisher. 4, 6, 7, 10, 12, 13, 19, 22, and 24. April 6 through October (probably year-round). Common especially in the spring on blackbrush. Also on mesquite and huisache. Reared from dead branches of blackbrush collected at 13.

30. *Chrysobothris basalis* Leconte. 1, 2, 3, 4, 5, 6, 7, 9, 10, 11, and 12. March 31 through October (probably year-round). Common on fresh dead and dying huisache. Also occurs on mesquite occasionally. Adults have been cut from dead tepehuaje on one occasion, but this should be considered exceptional since this *Chrysobothris* is distinctly partial to huisache.

31. *Chrysobothris octocola* Leconte. Taken at practically all

localities, January 21 through November (probably year-round). Undoubtedly the most common buprestid of the area. Usually on fresh dead and dying mesquite. Also occasionally on huisache, huisachillo, tree catclaw, and hackberry. This *Chrysobothris* is especially common about clearings and has been observed to swarm about smoldering mesquite legs.

32. *Chrysobothris purpureovittata* Horn. 6, 9, 20 and 22. April 3 through August. Usually on lote in which it very probably breeds. Also on dead ebony, fresh cut huisache and decadent granjeno.

33. *Chrysobothris viridiceps* Melsh. 8 and 10. May 15 through June. Common on fresh cut cedar elm in which this species breeds. Dead trunks riddled with characteristic-sized emergence holes, and adults cut from such trunks.

34. *Chrysobothris femorata* (Oliv.). 2, 5, 8 and 10. May 15 through June and September. Common on fresh dead and dying hackberry as well as on willow. Adults have been cut from both these trees. Although occurring in abundance at the same time and locality, this species and the preceding do not mingle at all. Each of these species is very specific in selecting its host plant.

35. *Chrysobothris exesa* Leconte. 19, 22, and 24. April 6 through April 17. Seven specimens, all from dead or dying branches of mesquite.

36. *Chrysobothris acuminata* Leconte. 6, 9, and 10. April 7 through June 15. Not common, on weakened mesquite.

37. *Chrysobothris acutipennis* Chev. 2, 3 and 4. May 26 through June and September. Rather common on fresh cut ebony, Gulf Coast guajillo and tepehuaje. Reared from tepehuaje branches pruned by *Oncideres pustulatus* Lec. two seasons previously.

38. *Chrysobothris merkelii* Horn. 4, 6 and 9. May through June and January 15. Common on fresh dead and decadent ebony and Gulf Coast guajillo.

39. *Chrysobothris analis* Leconte. 1, 2, 3, 4, 6, 7, 9, 10, 13, 16, 20 and 22. March 3 through November (probably year-round). Common on a variety of fresh dead and dying woody plants including huisache, ebony, guajillo, mesquite, granjeno, hackberry and cedar elm. Reared from tepehuaje, huisache and cedar elm.

40. *Actenodes flexicaulis* Schffr. 1, 3 and 4. April 13 through June 8. Of the eight specimens collected, five were on fresh dead or dying ebony. The remaining three were on brasil, granjeno and huisache, in the vicinity of ebony, however.

41. *Actenodes calcarata* (Chev.). 1, 4, 7 and 10. June 8 through August 19. Common on weakened huisache. The adults chew the bark of smooth branches forming conspicuous "abraded" patches. A sluggish species easy to collect.

42. *Actenodes mendax* Horn. 6 and 20. April 19 through July 9. Twelve specimens on decadent mesquite.

43. *Agrilus macer* Leconte. 2, 8 and 10. March 31 through June, August and September. Common on weakened and fresh dead hackberry trunks from which adults were cut on frequent occasions.



44. *Agrilus pulchellus* Bland. 9, 22, and 23. May 3 and 17, and September 1. Three specimens all in flight close to the ground, no *Erigeron* observed nearby.

45. *Agrilus exsapindi* Vogt. 8 and 10. March 31 through September 16. Frequent on foliage of soapberry early in the spring and occasionally thereafter. Adults emerged continuously, April through September, 1947 from a log chopped in April from a tree felled in the spring of 1946.

46. *Agrilus sapindicola* Vogt. 8. March 31 through April 5. Common during the short period indicated on tender new foliage of soapberry in company with 45 and 47.

47. *Agrilus ornatus* Horn. 8. March 31 through April 5. Common during the short period indicated on tender new foliage of soapberry in company with 45 and 46. A single specimen was also taken during late August. This species is suggestive in appearance of the ant *Cryptocerus angustus* Mayr. which commonly occurs on the same shrubbery at this locality.

48. *Agrilus felix* Horn. 20. April 6, 1947. A single female beaten from new mesquite foliage. Intensive collecting at this locality a week later failed to produce another.

49. *Agrilus obscurilimeatus* Vogt. 13. April 6 through April 20. Eight specimens collected on two blackbrush shrubs growing close together beside the Rio Grande City-Mission highway.

50. *Agrilus cupreonitens* Fisher. 1, 2, 8, 10 and 13. March 17 through July 20. Three specimens on blackbrush at 13. Three on mesquite and four on huisache at the remaining localities.

51. *Agrilus addendus* Crotch. 2, 8, 9, 10, 13 and Brownsville, March 17 through June 27, September. At 13 frequent on blackbrush remote from any huisache. At other localities mostly on huisache and occasionally on mesquite.

52. *Agrilus palmarcolis* Horn. 7, 8, 9, 22, 24 and Brownsville, March 23 through April 15. Frequent beating succulent spring foliage of mesquite. Usually in company with 53.

53. *Agrilus prosopidis* Fisher. 3, 7, 8, 9, 22 and Brownsville, March 17 through April 15. Uncommon beating succulent spring foliage of mesquite. Usually in company with 52. A single female was taken on a dead ebony branch on July 27 at 4.

54. *Agrilus neoprosopidis* Knull. 2. February 14 through April 18. Frequent on fresh cut branches and foliage of tepehuaje. Reared from the same tepehuaje branches mentioned under 27.

55. *Agrilus acaciae* Fisher. 2, 4, 6, 7, 8, 9, 10 and 13. April 6 through September. Frequent at 13 on blackbrush remote from any huisache. Common at other localities on huisache. Reared and cut from dead huisache.

56. *Agrilus lecontei celticola* Fisher. 1, 2, 4, 8, and 10. March 17 through August, but most common early in spring. At 1 and 4 several were taken on granjeno remote from any hackberry. At other localities common on hackberry. Also several from soapberry at 8.

57. *Agrilus lacustris* Leconte. 2, 4 and Boca Chica (along coast just north of the mouth of the Rio Grande). At Boca Chica common on seaside croton on October 19, 1946. At 2 and 4 on this same host plant during April and May.

58. *Agrilus eleanorae* Fisher. 13 and 19. April 6 through April 19. Three specimens at 13 on blackbrush and three specimens at 19 on guajillo coppice.

59. *Paragrilus texanus* Schffr. 2, 4, 6, 8, 9, 10 and 12. March 7 through September, especially in the spring. Common and general in its occurrence. Beaten and swept from huisache, tepehuaaje, mesquite and various herbs including callirhoe and other malvaceous plants. The fact that this species occurs frequently where malvaceous plants are absent would indicate it can be independent of them.

60. *Pachyschelus fisheri* Vogt. 4. June through September 13. Frequent on foliage of myrtle-croton the leaf of which the larva mines. The larva first tunnels along the very margin of the leaf, often completely around, and then crosswise back and forth up one half and then down the other. Pupation takes place within the leaf in a cell lined with coarse silk of low tensile strength. In the course of rearing the *Pachyschelus*, the author frequently obtained instead a chalcidoid parasite which Mr. A. B. Gahan<sup>4</sup> has identified as *Spalachalcis* near *odontotae* (How.).

61. *Taphrocerus agriloides* Crotch. East of 5. May 19, 1946. Common sweeping grasses and sedges along margin of a water hyacinth filled resaca.

62. *Taphrocerus Schaefferi* Nic. and Weiss. 2 and 10. March and July. Sweeping grasses.

63. *Taphrocerus* sp. near *gracillis* Say. McAllen, July. Sweeping grasses.

#### ADDENDA

Recorded from the Lower Rio Grande Valley are seven species of Buprestidae which the writer did not find. Including these, the total number of species known from the area is increased to 70. These additional species are listed below together with two other Texas species which may occur in the Lower Rio Grande Valley.

64. *Cinyra robustus* Chamberlin (1920). Described from a single specimen labeled "Texas".

65. *Agrilus subtropicus* Schffr. Described from Brownsville. Also reported by Knull (1937) from the same locality as occurring on capote.

66. *Agrilus lautuellus* Fisher (1928). Reported from the following Texas localities: San Diego, Zavalla, County, Nueces River, Sabinal, Devil's River, Del Rio and New Braunfels; April, May and June.

67. *Agrilus obolinus* Lec. Reported by Knull (1944) as being collected on foliage of hackberry at Brownsville.

68. *Agrilus esperanzae* Knull (1935). Described from a single specimen collected at Brownsville.

<sup>4</sup>Division of Insect Identification, Bureau of Entomology and Plant Quarantine.

69. *Agrilus dolli* Schffr. Described from Brownsville and reported by Fisher (1928) to occur on ebony during May and June.

70. *Agrilus muticus* Lec. Fisher (1928) reports this species from Brownsville and numerous other Texas localities. Adults are said to occur on *Callirhoe involucrata* Gray.

71. *Agrilus viridescens* Knull (1935). Described from a series of specimens found on mesquite at Brownsville.

72. *Trigonogya reticulaticollis* Schffr. (1904). Described from five specimens collected at Brownsville by C. H. T. Townsend and Ottmar Dietz.

#### FAUNAL CHARACTERISTICS OF THE SPECIES

In the following table is given the general distributional categories of most of the species.

OCCURRING IN THE SOUTHERN PARTS OF NEW MEXICO, ARIZONA, AND CALIFORNIA	PECULIAR TO THE RIO GRANDE VALLEY AND ADJACENT AREAS	OCCURRING IN THE LOWER AUSTRAL AND SUCCEEDING ZONES NORTHWARD
<i>Polycesta velasco</i>	<i>Acmaeodera uvaldensis</i>	<i>Acmaeodera pulchella</i>
<i>Acmaeodera gibbula</i>	<i>macra</i>	<i>tubulus</i>
<i>flavomarginata</i>	<i>miliaris</i>	<i>neglecta</i>
<i>rubronotata</i>	<i>flavinigrapunctata</i>	<i>Dicerca lurida</i>
<i>scalaris</i>	<i>obtusa</i>	<i>Chrysobothris femorata</i>
<i>quadrivittata</i>	<i>Paratyndaris chamaeleonis</i>	<i>purpureovittata</i>
<i>hulli</i> Knull	<i>Psiloptera cupreopunctata</i>	<i>viridiceps</i>
<i>Paratyndaris olneyae</i>	<i>Cinyra prosternalis</i>	<i>Agrilus lecontei</i>
<i>Hippomelas sphenica</i>	<i>Chrysobothris pubilineatus</i>	<i>lacustris</i>
<i>Psiloptera drummondii</i>	<i>acuminata</i>	<i>obolinus</i>
<i>Chrysobothris lixa</i>	<i>acutipennis</i>	<i>Taphrocerus agriloides</i>
<i>ephedrae</i>	<i>Actenodes flexicaulis</i>	<i>schaefferi</i>
<i>prosopidis</i>	<i>Agrilus subtropicus</i>	
<i>basalis</i>	<i>macer</i>	
<i>octocola</i>	<i>exsapindi</i>	
<i>exesa</i>	<i>sapindicola</i>	
<i>merkeli</i>	<i>ornatulus</i>	
<i>anal</i>	<i>esperanzae</i>	
<i>Actenodes calcarata</i>	<i>obscurilineata</i>	
<i>mendax</i>	<i>cupreonitens</i>	
<i>Agrilus pulchellus</i>	<i>prosopidis</i>	
<i>felix</i>	<i>neoprosopidis</i>	
<i>addendus</i>	<i>acaciae</i>	
<i>palmaecollis</i>	<i>dolli</i>	
	<i>viridescens</i>	
	<i>eleanorae</i>	
	<i>Paragrilus texanus</i>	
	<i>Pachyschelus fisheri</i>	

It is evident from this table that the buprestid fauna is largely Sonoran in character with only twelve species having a distribution extending northward into the Lower Austral and succeeding Zones. As far as known, of the remaining 52 species, 28 are peculiar to the Lower Rio Grande Valley and southward, whereas the remainder are known to extend westward as well as undoubtedly southward in their distribution, thus representing Lower Sonoran forms as generally accepted.

## HOST PLANTS ASSOCIATED WITH THE SPECIES

Except for most of the *Acmaeodera*, *Paragrilus* and *Taphrocerus* likely host plant associations have been made for most of the species of Buprestidae collected. A summary of these data is given in the following list:

Mesquite.....	18 spp.	Gulf Coast guajillo.....	2 spp.
Blackbrush.....	9	Cedar elm.....	2
Huisache.....	8	Capote.....	2
Ebony.....	6	Coyotillo.....	1
Hackberry.....	5	Willow.....	1
Granjeno.....	4	Ceniza.....	1
Tepehuaje.....	4	Lote.....	1
Soapberry.....	3	Seaside croton.....	1
Guajillo.....	3	Myrtle-croton.....	1

It is evident that several dominant woody plants serve to support the majority of the Buprestidae in this region. Aside from those listed above, a number of other dominant plants were found to be unproductive of buprestids despite close and frequent observation. These plants are as follows: *Mimosa Lindheimeri*, *M. Wootoni*, *M. biuncifera*, palo verde, retama, allthorn, colima, amargosa, brasil, ash, Mexican olive, anacua, guayacan and coma.

It is interesting to note that all of the 12 northern forms of Buprestidae are associated with host plants which likewise have a northern distribution or else have congeneric forms with a northern distribution. This same parallelism holds true with the buprestids ranging westward. On the other hand, only three of the species peculiar to the Lower Rio Grande Valley affect plants largely confined to the area; i.e., insofar as distribution northward and westward is concerned.

## SEASONAL OCCURRENCE OF THE SPECIES

From the annotated list of species it is evident that the majority of the Buprestidae of the Lower Rio Grande Valley may be classed into a number of categories with regard to their seasonal occurrence. These categories represent those species occurring primarily in (1) early spring (February, March and April); (2) spring (April, May and early June); (3) early summer (May, June and July); (4) summer (June, July and August); (5) early fall and fall (September, and October); (6) fall and early winter (October, November, and December); (7) early spring through fall (April through October); and (8) year-round.

In general most of the *Agrilus* belong in (1) and (2), *Hippomelas* in (5) and (6), *Psiloptera* in (4), (5) and (6), *Polycesta* in (3), *Cinyra* in (4), *Actenodes* in (3), and *Pachyschelus* in (7). Some *Chrysobothris* belong in (1), others in (3) and (4), and still others in (7) and (8). The *Acmaeodera* break down into four short period groups, namely, those in (1), those in (2), those in (3), and those in (5).

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VIRAL AND RICKETTSIAL INFECTIONS OF MAN, edited by THOMAS M. RIVERS with 27 contributors. 587 pages, 31 charts, 46 figures and 6 plates in color. J. B. Lippincott Company, Philadelphia, London, Montreal. 1948. \$5.00.

The field of viruses and rickettsia has for many years been in such a state of change that it was difficult for workers in other areas to maintain even a general picture of the diseases produced by these agents. As indicated in the preface of this work, it was the intent of the editor to bring together the opinions of outstanding workers in each group of these diseases. This has been admirably done and there is a great deal of general agreement that has been reached. Many of the older conflicting views have been reconciled in light of more recent developments so that altho there obviously remains a great deal to be learned, many of the obstacles have been partially or completely removed with some of the newer techniques. Since a large number of the viral diseases and the majority, if not all, of the rickettsial infections are transmitted from one host to another by insect or other arthropod vectors a work of this type will be of value to entomologists working in medical entomology and related fields. However, the entomological side of the problem receives little attention other than a listing of the known or suspected arthropods involved for a particular infection, with some brief mention of factors affecting natural and experimental transmission.

As indicated in the title, only diseases affecting man are covered, but these include diseases that rarely attack humans altho they may be common in other animals. An exception to this is the chapter on bacterial viruses or bacteriophages. Each disease is discussed under a number of subheadings including: Introduction, History, Clinical Picture, Pathological Picture, Etiology, Diagnosis, Treatment, Epidemiology, and Control Measures. The first six chapters are devoted to a general discussion and techniques used in the study of these agents, with a chapter on Epidemiology. These would be of particular value to workers from another field whose investigations might extend into this area.

Altho the book was primarily written for medical students and practicing physicians it should find a place on the desk of many research workers in adjoining areas. An excellent bibliography to recent work and the more pertinent older contributions is found at the end of each chapter. Because the publication of this text was subsidized by The National Foundation for Infantile Paralysis, it is sold at a price which will make it much more attractive to the individual who might wish to have a copy for occasional reference to subject matter mostly outside of his major interests. The low price is in no way a measure of the quality of the work or of the printing itself. The only criticism the reviewer finds, in view of the special nature and purpose of the text, is that more illustrations might have been provided in several of the chapters.—CHARLES H. DRAKE.

# STUDIES ON THE INTERNAL ANATOMY OF THE BOX ELDER BUG, *LEPTOCORIS TRIVITTATUS* (SAY)

(Hemiptera, Coreidae)<sup>1, 2</sup>

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## INTRODUCTION

The box elder bug, *Leptocoris trivittatus* (Say), has been of interest to the writer for some time since representatives of Hemiptera are known to exhibit a diversity of internal structures. The writer undertook the problem of studying the internal morphology of this insect out of curiosity and a general interest in morphology.

## MATERIALS AND METHODS

Insofar as possible dissections were made on live insects which had been injected with a vital stain. In the latter technique trypan blue was found to give the best results of a series of stains used and required a minimum of time to become effective. Levy's solution was used to wash off excess stain and to cover dissected insects.

Kahle's and Carnoy's solutions were employed to fix whole insects and dissected organs. The latter were washed and preserved in seventy per cent alcohol. Fixed insect and tissues were dehydrated in alcohol, cleared in xylene and imbedded in paraffin. Sections of the imbedded materials were cut at 5, 7, and 10 microns.

The histological stains used in the problem included Delafield's hematoxylin, fast green (FCF), Hansen's trioxymethine, Heidenhain's iron hematoxylin and picro-fuchsin.

The drawings of gross structures were made free-hand. The writer used both dissected specimens and stained whole mounts for this purpose. All histological drawings were made with the aid of a camera lucida. The details of the drawings were filled in after a general outline had been made.

## THE DIGESTIVE TRACT AND ASSOCIATED STRUCTURES

Breakey (1936), Hood (1937) and Harris (1938) in describing the digestive structures of various Hemipterans, list the regions of the digestive tract of these insects in slightly different ways, but all of them demonstrate the same general regions and areas of the alimentary canal.

Elson (1937) divides the alimentary canal of *Leptocoris* into the three principal regions generally designated in insects and states that

<sup>1</sup>Part of dissertation presented for degree of Doctor of Philosophy, Department of Zoology and Entomology, The Ohio State University.

<sup>2</sup>Sincere appreciation is extended to Dr. Clarence H. Kennedy, for his encouragement and support of the work. The author also expresses his deep gratitude to Mr. George F. Edmunds, Jr., and Miss Alvira Woolley, who supplied insects used in the study.

the digestive tract of this insect "is of moderate length, being approximately twice the length of the body."

In this paper the alimentary tract of *Leptocoris* is divided into the following regions:

- I. STOMODAEUM
  - Pharyngeal Pump (Cibarium)
  - Pharynx
  - Salivary Glands
  - Oesophagus
- II. MID-INTESTINE
  - 1st Stomach ( $M_1$ )
  - 2nd Stomach ( $M_2$ )
  - 3rd Stomach ( $M_3$ )
  - 4th Stomach ( $M_4$ )
- III. PROCTODAEUM
  - Ileum
  - Malpighian Tubule Diverticulae
  - Malpighian Tubules
  - Rectum
  - Rectal Diverticulum (cul-de-sac)

### *The Stomodaeum*

The pharyngeal pump is a sclerotized, wedge-shaped tube, which has an inverted dorsal ridge for about one-third its length. The pharyngeal pump then becomes tubelike (Plate II, figs. 2, 3) and merges with the pharynx. The pharynx is widened at its anterior end but tapers at its caudal extremity before the union with the oesophagus immediately posterior to the brain (Plate II, figs. 2, 4). At this junction the pharynx exhibits a slightly bulbous portion (Plate V, fig. 18) which has muscle attachments distinct from those of the pharyngeal pump. This pair of muscles projects laterally from each side of the bulb and attaches to the apodemes of the head.

Dilation of the pharyngeal pump is accomplished by two sets of muscles attached to its dorsal ridge. The elasticity and inverted shape of the sclerotized portion of the pump are sufficient to return the pump to its trough-like shape (Plate II, fig. 2) and while the writer assumes these muscles to be adequate for the pharyngeal pumping action, it appears that the small set of muscles at the distal dilation of the pharynx function in an auxiliary fashion. This assumption is further substantiated by noting that the bulbous portion of the pharynx is found posterior to the brain. The narrowed end of the pharynx extends through the brain before it joins the thin-walled oesophagus. This smaller set of muscles implies an added force behind the anterior dilator muscles of the pharyngeal pump in forcing or moving fluids through the pharynx to the oesophagus.

### *The Salivary Glands*

There are two pairs of salivary glands in the box elder bug, the primary and the accessory glands. The primary salivary glands are large, four-lobed structures lying in the cavities of the lateral portions of the metathorax and the first abdominal segments. These glands are translucent and whitish in color, their lobes slightly irregular in shape.

In a cluster of the lobes the anterior and posterior extensions are wiener-shaped and elongated while the lateral lobes are pyriform or rounded (Plates I & V, figs. 1, 18). From each cluster a long cylindrical salivary duct extends cephalad. Each salivary duct lies ventral to the oesophagus and terminates in a common duct. The latter enters the salivary syringe (Plate V, fig. 18), but one notes that in histological section (Plate II, fig. 4) the two ducts remain separate for some distance in the ventral portion of the syringe before they fuse. In gross dissection the common duct appears single.

Adjacent to each salivary duct and easily confused with it, is an elongated, slightly coiled tube, the accessory salivary gland (Plate V, fig. 18). This narrow, cylindrical gland empties into the duct entrance of the principal salivary gland (Plate V, figs. 21, 22). The accessory gland extends forward into the thorax and head, where the gland turns and extends posteriorly. The free end of the accessory gland lies in the thoracic cavity.

The salivary syringe is a chitinous, cylindrical structure (Plates I, II, V, figs. 1, 2, 19). The syringe lies ventral to and connects with the pharynx at its anterior end. Elson (1937) describes the salivary pump as a distinguishing characteristic of phytosuccivorous forms of Hemiptera.

The posterior wall of the salivary syringe is invaginated and forms a piston-shaped structure. The syringe is dilated by a set of muscles attached to the posterior extension of this piston by a tendinous attachment. The dilator muscles have their origin on the tentorium near the rear of the cranial cavity (Plate II, fig. 2).

The oesophagus is short and thin-walled. It lies in the general neck region, and while it is difficult to determine exactly where the organ ends in gross section when the stomach is deflated, histologically the oesophagus is seen to end in a valve-like constriction. The latter is somewhat like the one described for *Anasa tristis* by Breakey (1936). At this point the oesophagus joins the large ventriculus or stomach ( $M_1$ , figs. 1, 2, 6).

#### *The Mid-Intestine*

The ventriculus or stomach proper ( $M_1$ ) is situated in the thorax between the lateral masses of thoracic muscles; it is large and sac-like. The ventriculus extends from the prothorax to the region of the second abdominal segment and lies above the ventral ganglia. When the ventriculus becomes dilated, it fills the thoracic cavity. The walls of the ventriculus are frequently folded when it is empty. The longitudinal compression is accomplished by two strands of longitudinal muscles running the length of the ventriculus and forming a dorsal and ventral median raphe (Plate I, fig. 1).

The ventriculus or first stomach narrows abruptly into a tubular portion of the mid-intestine, the second stomach ( $M_2$ ), which is directed anteriorly. The second stomach extends to the area of the first abdominal segment, turns abruptly caudad and joins the enlarged, slightly inflated portion of the mid-intestine, the third stomach ( $M_3$ ). The latter becomes constricted at its posterior end and merges with the fourth stomach ( $M_4$ ). The fourth stomach is short and bulbous and joins the



ileum. At this junction the histological structure appears valve-like, which will be discussed later. The fourth stomach normally bears gastric caecae, but there are none in *Leptocoris*. Both Elson (1937) and Breakey (1936) point out, however, that *Anasa tristis*, a member of the same family, Coreidae, has these structures.

### *The Proctodaeum*

The ileum, between the rectum and the mid-intestine proper, is a short and balloon-like region in the live insect. Glasgow (1914) describes the ileum in all species, but Snodgrass (1935) questions the use of the term in insect anatomy.

A pair of diverticula is produced laterally from the ileum. Four Malpighian tubules attach to these diverticula, two tubules arising from a common stalk or peduncle leading to each diverticulum. The tubules are coiled on the dorsal inner surface of the abdominal cavity, entwining themselves around the alary muscles of the heart, through the openings in the dorsal diaphragm and between the surrounding fat bodies.

### EXPLANATION OF PLATE I

FIG. 1. Ventral view of displaced digestive system, salivary glands and Malpighian tubules (semi-diagrammatic).

### ABBREVIATIONS USED ON PLATES

AC GL—accessory gland	OD L—lateral oviduct
ANT NV—antennal nerve	OD M—median oviduct
AO—aorta	OES—oesophagus
BR—brain	OVL—ovariole
CA—corpus allatum	PED—pedicel
C MS—circular muscle	PHAR PMP—pharyngeal pump; cibarium
C SAL D—common salivary duct	PIS—piston
DIL MS—dilator muscle	P-MS-TH-GNG—pro-mesothoracic ganglion; ("central ganglion")
E CL—egg cell	PROT—protozoa
EJ D—ejaculatory duct	PR VLV—proctodaeal valve
E NU—egg nucleus	P SAL GL—principal salivary gland
EP TH—epithelium	P-TH-GNG—prothoracic ganglion
F B—fat body	PT M—peritoneal membrane
FOL—follicle	REC—rectum
GNG—ganglion	REC DIV—rectal diverticulum
GRM—germarium	SAL D—salivary duct
IL—ileum	SAL SYR—salivary syringe
INT—intima	S B—striated border
L MS—longitudinal muscle	SEC—secretion
LU—Lumen	S LIG—suspensory ligament
M <sub>1</sub> —ventriculus proper; first stomach	SPD—spermatid
M <sub>2</sub> —second stomach	SPT—spermatheca
M <sub>3</sub> —third stomach	SPZ—spermatozoa
M <sub>4</sub> —fourth stomach	ST VLV—stomodaeal valve
M T—Malpighian tubule	S V—seminal vesicle
M T DIV—Malpighian tubule diverticulum	TENT—tentorium
N—nucleus	TR—trachea
NR CL—nurse cell	VAC—vacuole
NR TB—nutritive tube	V D—vas deferens
OC—ocellus	

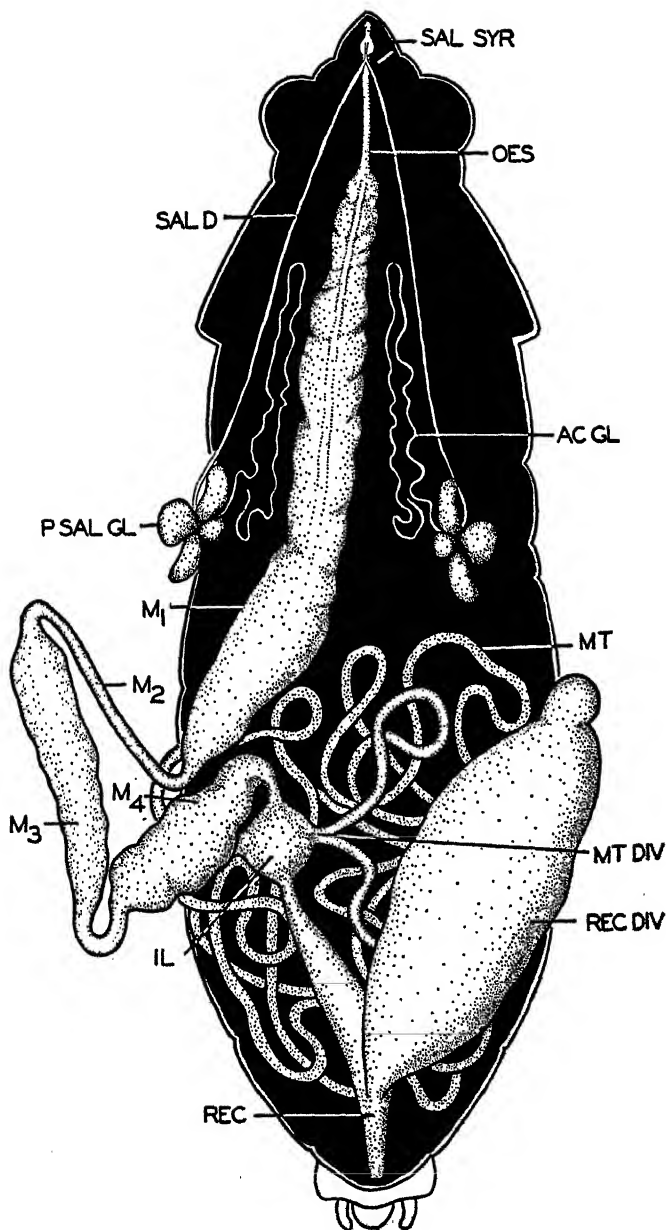


FIG I

The duct or lumen within the semi-transparent tubules appears to be spiralled. The orange-colored contents of the tubules were observed by the writer to pass down the ducts in an irregular, wave-like motion along a spiral path. Later histological studies of the Malpighian tubules revealed an arrangement of cells which formed a spiral duct (Plate IV, fig. 15).

The movements of the contents of the tubules suggests a muscular action within the tubules similar to peristalsis. However, Harris (1938) states that he found no muscle in the Malpighian tubules of *Murgantia histrionica* and the writer did not observe any in *Leptocoris*.

The ileum is connected directly to the rectum, which has a ventral diverticulum or cul-de-sac. The rectal sac is blind and is normally rather small. However, it may become distended and may nearly fill the abdominal cavity (Plate I, fig. 1). This sac and the rectum usually contain many protozoa. The writer does not intend, however, to describe these symbionts inasmuch as a work has been published on that problem by Kay (1942).

#### HISTOLOGY OF THE DIGESTIVE TRACT AND ASSOCIATED STRUCTURES

##### *Stomodaeum*

The pharyngeal pump and the pharynx are composed of hypodermal cells which stain very darkly, and a thin, clear intima. The same general histology is noticeable in both the pharyngeal pump and the pharynx from the anterior, trough-like area of the former to the junction of the pharynx with the oesophagus.

The bulbous portion of the pharynx posterior to the brain is surrounded by several bands of circular muscles. The arrangement of these muscles is suggestive of a sphincter.

##### *The Salivary Glands*

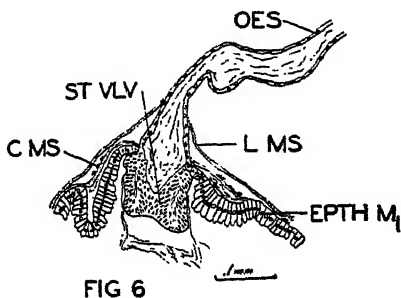
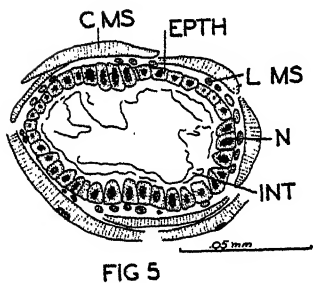
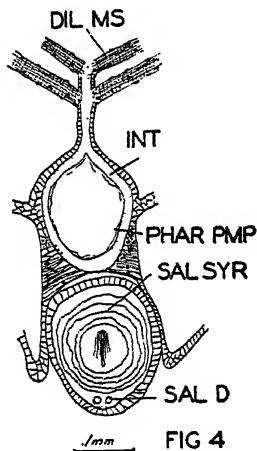
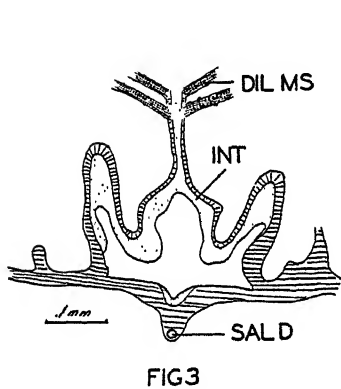
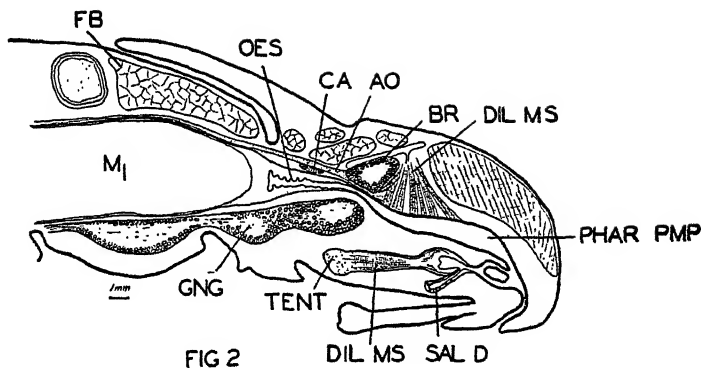
The main salivary glands of the box elder bug consist of four lobes (Plates I, V, figs. 1, 18). Each lobe is surrounded by a thin membrane and the entire cluster is enclosed in a thin sheath of tissue. These encasement tissues are the same for all lobes. They are thin and have scattered, elliptical nuclei. In this regard the box elder bug resembles the squash bug, described by Breakey (1936).

The epithelium of the principal glands is cuboidal, and all of the cells of the four lobes are similar. The nuclei of the cells are large and in some instances there were more than one within a cell. The cytoplasm of the salivary epithelium is extremely granular and stains very darkly. The inner border of the cells is much darker than the remaining

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#### EXPLANATION OF PLATE II

FIG. 2. Sagittal section of head and prothorax, showing position of internal organs. FIG. 3. Cross section of the pharyngeal pump anterior to the brain (semi-diagrammatic). FIG. 4. Cross section of the pharyngeal pump and salivary syringe. FIG. 5. Cross section of the oesophagus posterior to the brain. FIG. 6. Longitudinal section of the stomodaeal valve, showing area of chitinous secretion.



portion. The inner border of the salivary epithelial cells resembles the striated epithelium of the mid-intestine ( $M_2$ ).

The salivary duct and the accessory salivary gland both have heavy, chitinous intimas (Plate V, fig. 20). In section the writer was unable to distinguish between the salivary duct and the accessory gland. The cuboidal cells of the two are identical and form a compact ring around the intima. The nuclei of the cells are round and the cytoplasm appears striped. The strands of the striping extend perpendicular to the axis of the ducts. A thin peritoneal sheath invests both the accessory gland and the salivary duct. This peritoneal sheath is continuous with the covering of the principal glands.

The salivary ducts and the accessory glands fuse at a common junction in a ring of cells in the principal gland. The writer has designated this ring of cells as the common salivary duct. The intima of the latter is continuous with the intimas of the accessory gland and the salivary duct. The ring cells of the common duct are cuneiform. They are wider at the base than at the lumen ends. The nuclei of the ring cells are small and basally located. The cytoplasm of these cells is clear.

The oesophageal epithelium begins immediately posterior to the band of muscles described around the bulbous portion of the pharynx. A cross section of the oesophagus in this region posterior to the brain shows a shallow intima of chitin with an encircling layer of epithelial cells. The epithelial cells are cuboidal in shape. They contain large, ovoid nuclei (Plate II, fig. 5). They rest on a thin basement membrane outside of which are the layers of longitudinal and circular muscles, respectively. The circular muscles predominate and are fewer in number than those encircling the bulbous portion of the pharynx.

The stomodaeal valve of the box elder bug (Plate II, figs. 2, 6) is rather well defined in histological section, but the cells are poorly differentiated from either the oesophagus or the mid-intestine. Because of the folds of the epithelium at this point, it is difficult to get a section which shows more than the syncytial-appearing arrangement shown in fig. 6. The nuclei are rather close together and appear very similar in shape and arrangement to the nuclei of the proctodeal valve (Plate IV, figs. 13, 14, 16). The stomodaeal valve is a many-folded projection of the stomodaeum into the mid-intestine at the junction of the oesophagus and the ventriculus ( $M_1$ ). At this point the epithelium of the oesophagus is met by the columnar epithelium of the ventriculus.

From the ring of cells formed in the fold of the stomodaeal valve there is a slight secretion of chitin evidenced. As indicated in figure 6, however, this chitin extends only a short distance. It resembles an

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#### EXPLANATION OF PLATE III

FIG. 7. Cross section of epithelium of distended ventriculus ( $M_1$ ). FIG. 8. Cross section of epithelium of normal, undistended ventriculus ( $M_1$ ). FIG. 9. Epithelial cells of the second stomach ( $M_2$ ) showing protozoa in the lumen. FIG. 10. Cross section of third stomach ( $M_3$ ), showing epithelium with striated border and vacuoles. FIG. 11. Epithelium of  $M_3$  enlarged to show striated border and vacuoles. FIG. 12. Longitudinal section of Malpighian tubule diverticulum, showing transition of epithelial cells.

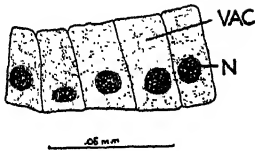


FIG 7

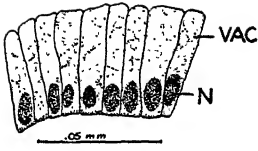


FIG 8

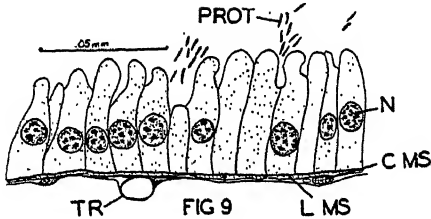


FIG 9

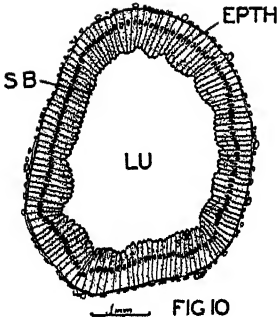


FIG 10

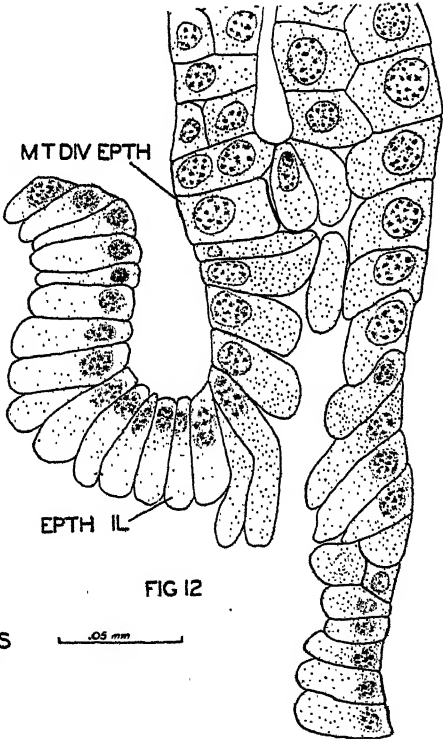


FIG 12

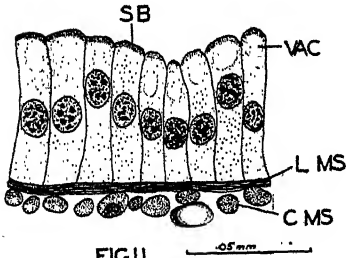


FIG 11

arrested membrane and might be a remnant of the peritrophic membrane although no developed peritrophic membrane was found in the box elder bug.

The writer would suppose that these cells at the junction of the stomodaeum and the ventriculus indicate an area in which a peritrophic membrane may have been secreted. It is also interesting to note that the junction is similar to the one described for *Anasa tristis* by Breakey (1936).

#### Mid-Intestine

The cells of the ventriculus or stomach proper ( $M_1$ ) are quite different from the cuboidal epithelium of the oesophagus. The ventricular epithelium cells are columnar and vacuolated. The nuclei of these cells are oval and the cytoplasm is granulated.

When the stomach is inflated or has become distended by the ingestion of food or air, the cells lose their typical columnar shape. They become distorted into near-cuboidal contours; the nuclei become round. The general appearance of the nuclei and the cytoplasm otherwise remains about the same.

The distensibility of the ventriculus is remarkable. The writer has noted that it may occur by means of the intake of air by the insect. Some of the fixed specimens and the fresh insects used in dissections demonstrated large air bubbles distending the stomach to about twice the normal size.

The epithelium of the second, more tubular portion of the mid-intestine, the second stomach ( $M_2$ ), is rather unique (Plate III, fig. 9). The cells are columnar and their distal ends are distorted to form crypts and pockets between the cell boundaries. In these entad or lumen pockets there are numerous protozoa. These organisms appear to be the same type found in the more posterior regions of the digestive tract, the ileum and the rectum.

The nuclei of the epithelial cells of the second stomach are round and the cytoplasm is only slightly granular. The longitudinal and circular muscles are opposite in arrangement to those of the ventriculus. The circular muscle layer is outermost, which is the reverse of the arrangement of the muscle layers of the ventriculus.

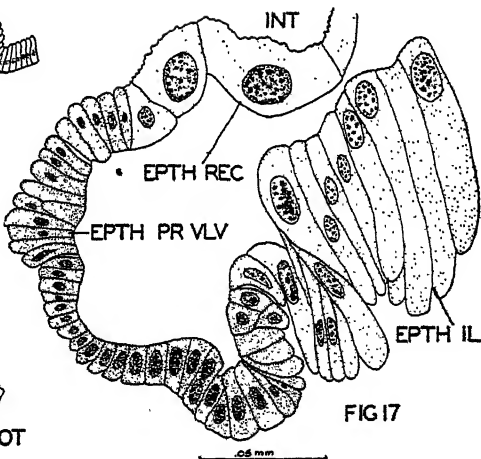
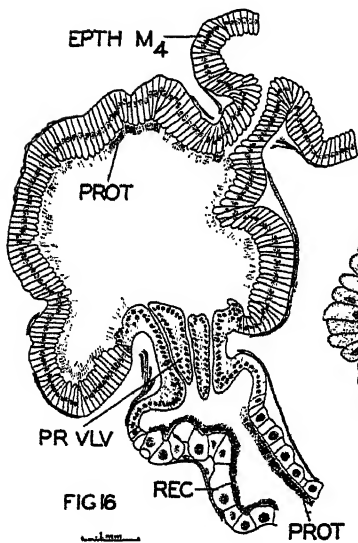
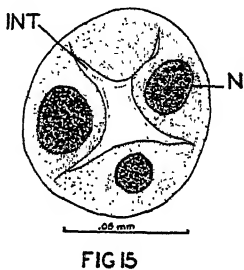
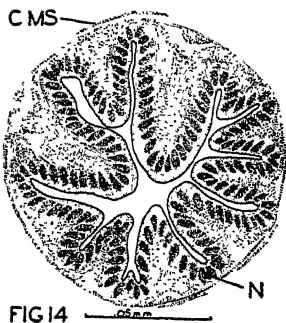
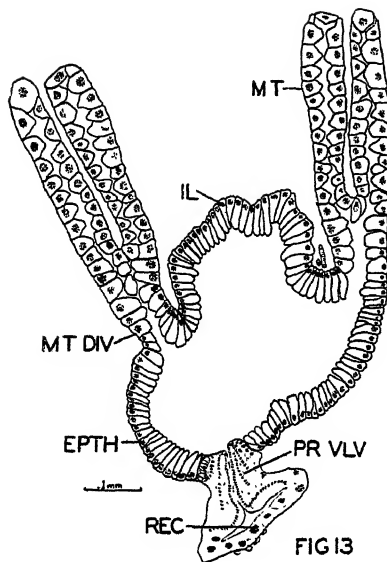
The third portion of the mid-intestine, the third stomach ( $M_3$ ), is the only area of the digestive tract in which the writer found epithelium with a distinct striated border. The cells of this region are columnar with circular, centrally placed nuclei. The entad ends of the cells are vacuolated. Usually there is one large vacuole present in the distal end of each cell (Plate III, figs. 10, 11).

The fourth portion of the mid-intestine, the fourth stomach ( $M_4$ ), and the ileum (Plates I, IV, figs. 1, 13, 16) have columnar epithelium.

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#### EXPLANATION OF PLATE IV

FIG. 13. Tangential section of ileum, Malpighian tubule diverticulum and rectum. FIG. 14. Cross section of the proctodaeal valve. FIG. 15. Cross section of Malpighian tubule. FIG. 16. Vertical section of ileum, Malpighian tubule diverticulum and rectum, showing proctodaeal valve. FIG. 17. Portion of the proctodaeal valve showing transition of epithelium.





The lumen ends of the cells are light in color and the nuclei are more generally central in location.

The writer assumes that the layers of epithelium between the fourth stomach and the ileum might function as a valve (Plate IV, fig. 16). This valve may function in the control of food material passing into the ileum and may restrict the movement of large numbers of protozoa anteriorly to the mid-intestine. No protozoa were observed in the fourth stomach, although a few were noted in the second portion of the mid-intestine ( $M_2$ ), which has crypts in the epithelium.

### *Proctodaeum*

The ileum of the box elder bug is a spherical structure. It marks the junction between the mid-intestine and the rectum. The ileum is the organ from which the Malpighian tubule diverticula extend.

It is interesting to observe that the two pairs of Malpighian tubules in the box elder bug share a common stalk or attachment to the ileum. Breakey (1936) describes these tubules in *Anasa tristis* with separate attachments for each tubule. Hood (1937) and Harris (1938) indicate the condition of separate attachments also.

Just as interesting is the histology of this particular region. The epithelium of the junction of the Malpighian tubules with the ileum is distinctive. The shape of the epithelial cells at the junction of the ileum and the Malpighian tubule diverticula changes abruptly (Plates III, IV, figs. 12, 13, 16). There are columnar cells in the ileum, near-columnar to cuboidal cells in the diverticula and cuboidal or polygonal cells in the tubules.

Within the lumen of the ileum there are numerous protozoans near the lumen ends of the cells. These protozoans are also found in the rectum. The organisms seem peculiar to the ileum and the rectum, although a few have been mentioned previously in this writing in the second stomach ( $M_2$ ). The work by Kay (1942) describes them.

### *Malpighian Tubules*

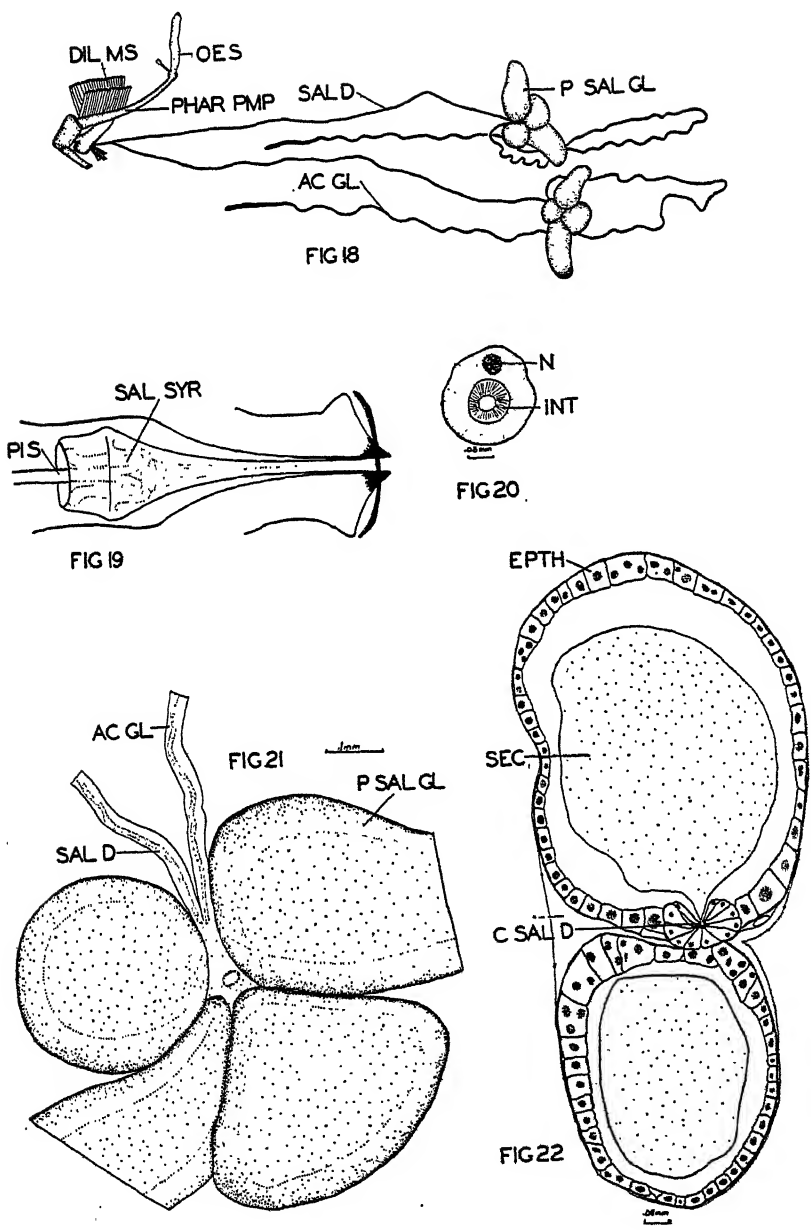
The cells of the Malpighian tubules (Plate IV, fig. 15) are polygonal or cuboidal in shape. The nuclei are large and stain much darker than those of the digestive tract. The cytoplasm of the tubule cells also stains darker than usual and contains many inclusions.

The cells are arranged in a triangular or tripod arrangement. Two cells on one side of the tubule oppose a third cell across from them. The latter cell is slightly offset proximad or distad of the other two. Such an alternation of the cells of the tubule would account for the spiralling of the inner duct described earlier by the writer.

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### EXPLANATION OF PLATE V

FIG. 18. Lateral view of dissected pharynx, salivary syringe and salivary glands (semi-diagrammatic). FIG. 19. Ventral view of dissected salivary syringe and piston. FIG. 20. Cross section of salivary duct. FIG. 21. View of portion of principal salivary gland, showing common duct of salivary duct and accessory gland. FIG. 22. Cross section of principal salivary gland showing epithelium and common duct opening.



The cells are enclosed by a tight basement membrane. Their inner margins have a clear, thin intima. A striated border, so typical of Malpighian tubules of many insects, was not observed in *Leptocoris*. However, Wigglesworth (1947) states that fixation of these structures renders the border invisible, hence these tubules may have such a border, but the writer has not observed it.

At the junction of the ileum and the rectum there is a distinct valvular arrangement of cells which the writer has called the proctodaeal valve. The epithelium of the structure is folded inwardly and forms a narrow opening. The lumen of this valve appears somewhat rosette-shaped (Plate IV, figs. 13, 14, 16). Between the folds of the valve and the epithelium a connective tissue was observed. This was the first of this type of tissue found by the writer in the digestive tract of *Leptocoris*.

The epithelium of the proctodaeal valve is differentiated from both the epithelium of the ileum and that of the rectum (Plate IV, fig. 17). The cells of the valve are low columnar or cuboidal, smaller than the cells of either the ileum or the rectum, and stain darker than either of the other types of cells. The nuclei of the valve epithelium are distinctly ovoid or tear-drop in shape. The cell membranes are indistinct in many portions of the valve, especially in the cross section (Fig. 14). The connective tissue which lies outside the epithelium appears in long strands. The epithelial cells rest on a thin basement membrane and muscular elements of both circular and longitudinal types are noticeable. The longitudinal muscles are more prevalent than the circular muscles.

The rectum in the box elder bug is differentiated into two distinct regions, the rectum proper and the cul-de-sac or the rectal diverticulum (Plate I, fig. 1). Both of these structures have the same histological makeup.

The epithelium of the rectum and rectal diverticulum is made up of large cells with large nuclei. The inner margins or lumen edges of the cells show a chitinous intima. The latter is similar to the intima of the oesophagus (Plate IV, fig. 17). The inner margins of the cells appear to be trough-like and the protozoa previously mentioned are copiously packed in these trough-like folds (Plate IV, fig. 16).

#### THE FEMALE REPRODUCTIVE SYSTEM

Essig (1942) states that the female Hemiptera have from four to seven ovarioles, a spermatheca and two or three accessory glands. The ovaries of the order Hemiptera are typically acrotrophic or telotrophic, i.e., the nurse cells are located at the apex of the ovarioles. The spermatheca and the accessory glands may be globular or tubular.

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#### EXPLANATION OF PLATE VI

FIG. 23. Longitudinal section of ovariole, showing egg cells, nutritive cells and tubes, and follicle. FIG. 24. Dorsal view of oviducts and spermatheca. FIG. 25. Longitudinal section of oviduct wall. FIG. 26. Ventral view of female reproductive organs.

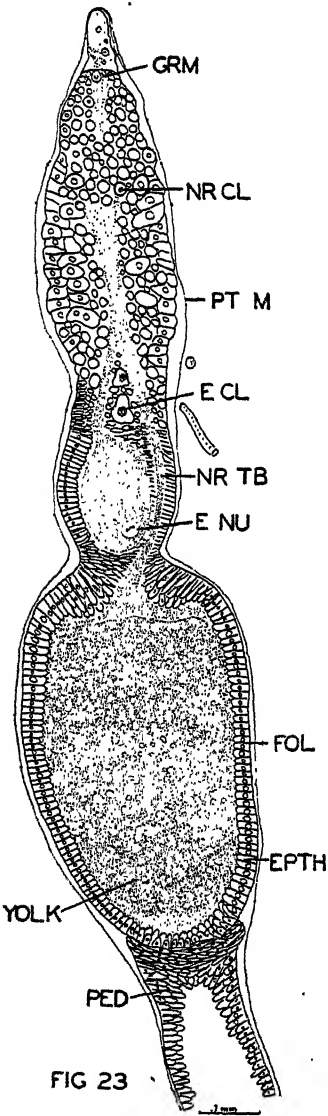


FIG 23

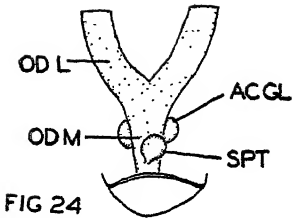


FIG 24

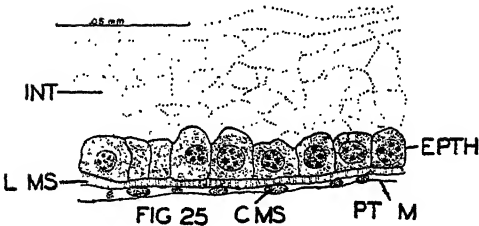


FIG 25

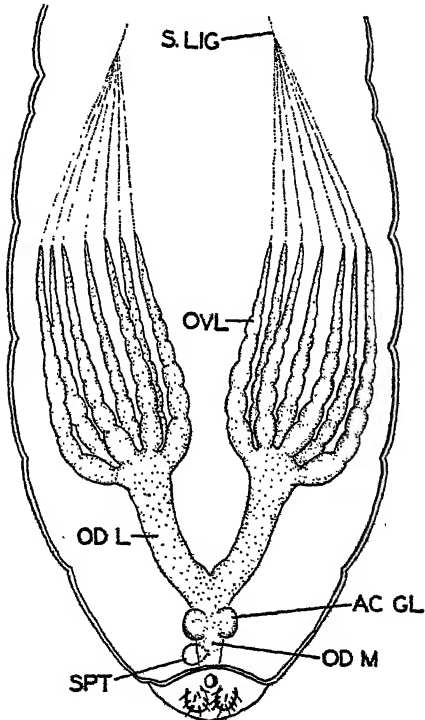


FIG. 26

The yellow-colored ovaries of *Leptocoris* have seven ovarioles (Plate VI, fig. 26). These ovarioles are clustered about the anterior portions of the two lateral oviducts in a radial manner, so that when the terminal filaments are broken or cut, the ovarioles tend to resemble the spokes emanating from the hub of a broken, rimless wheel. The terminal filament of each ovariole joins adjacent filaments anteriorly to form a suspensory ligament. This ligament attaches to the dorsal body wall of the prothorax. The single suspensory ligament holds the ovarioles in a cone-like arrangement. The base of the cone thus formed is continuous with the lateral oviducts. The suspensory ligaments support the ovaries in the body cavity. However, the main support of the ovaries in *Leptocoris* is furnished by the numerous tracheae from the second abdominal spiracle. There are eleven such branches emanating from the trachea of each of the second abdominal spiracles.

The two lateral oviducts fuse posteriorly to form a common, median oviduct, which extends to the outside by way of the gonopore. The median oviduct bears dorsally the bulbous spermatheca which is attached to the oviduct by a short stalk (Plate VI, figs. 24, 26). There are two bulbous accessory glands attached slightly anterior and ventral to the location of the spermatheca on the median oviduct. These glands, which are assumed to function in egg laying, attach to the median or common oviduct by short peduncles.

#### THE HISTOLOGY OF THE FEMALE REPRODUCTIVE SYSTEM

The ovarioles of *Leptocoris* conform to the general pattern indicated by Riley (1907), Snodgrass (1935) and Wigglesworth (1947). The ovariole consists of a terminal filament, a germarium and a zone of growth or vitellarium. Riley includes all three, Snodgrass unites the latter two and Wigglesworth adds an *ovariole stalk* to the former three.

The terminal filament of *Leptocoris* is formed by connective tissue in a sheath which also surrounds the ovarioles and is continuous with the covering of the ovary.

The germarium is set off from the terminal filament by a distinct membrane, according to Riley (1907), and contains germ cells exclusively. There is such a membrane in *Leptocoris* (Plate VI, fig. 23), although there are also nurse cells in the apical end of the ovariole.

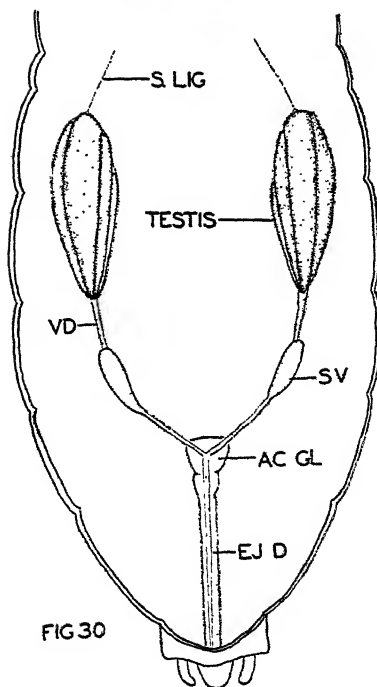
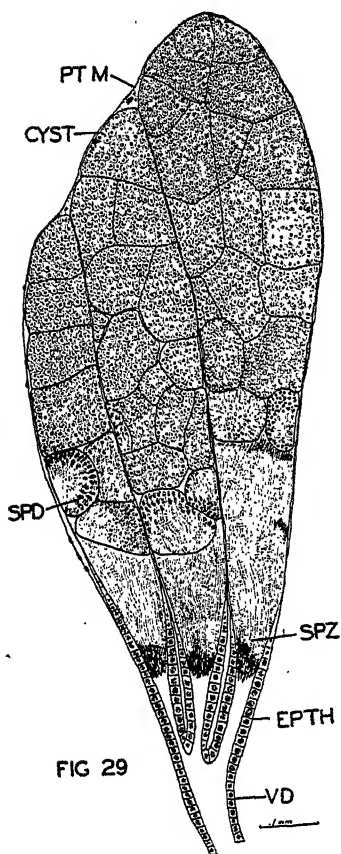
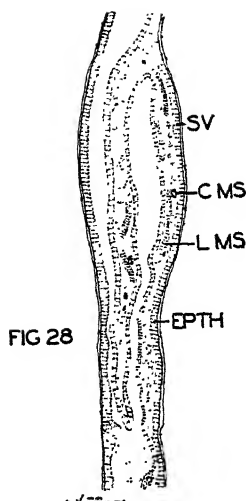
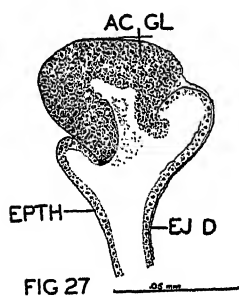
The nurse cells are found in the distal portion of the ovariole. Long strands or cords of material project from them to the developing oocytes in the follicular portions of the ovarioles (Plate VIII, fig. 30). The nurse cells and the germ cells make up the apical portion of the ovariole.

Each oocyte is enclosed by follicular epithelium and becomes larger as it moves down the egg tube toward the oviduct. An oocyte contains an abundance of nutritive material which stains darkly. The nucleus

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#### EXPLANATION OF PLATE VII

FIG. 27. Longitudinal section of male accessory gland and ductus ejaculatorius. FIG. 28. Longitudinal section of vas deferens and seminal vesicle, showing muscular elements and epithelium of seminal vesicle. FIG. 29. Longitudinal section of testis, showing three follicles and anterior portion of vas deferens. FIG. 30. Male reproductive organs, ventral aspect.



of the oocyte is found in the basal portion of the cell, (Plate VI, fig. 23). It is round, translucent and only slightly pigmented, and contrasts markedly with the nutritive element of the oocyte.

The follicular epithelium surrounding the oocytes rests on a thin basement membrane. The cells of this follicular epithelium are columnar except at the ends of the oocyte, where they become flattened and resemble stratified squamous cells. The nuclei of the follicular cells stain darkly and are centrally located. The nuclei are rounded in the columnar cells and oval in the flattened cells. The cytoplasm of the follicular cells is extremely granular. The writer assumes the follicular epithelium of *Leptocoris* to be secretory.

The yolk or nutritive material within the immature oocytes is denser than the same material in mature oocytes. The yolk of the latter is vacuolated and finely granular. The nutritive material of the mature oocyte becomes separated from the nutritive cord of the apical nurse cells. The yolk of the mature oocyte and the nutritive cord appear to be different in composition and hence stain differently.

The mature oocyte rests within a follicle and upon a peduncle or plug of cells. The latter is composed of oviduct cells which are compressed in a manner similar to the cells at the ends of each follicle. When the oocyte is ripe, it ruptures the epithelial plug of the follicle and passes into the oviduct (Plate VI, figs. 23, 26).

The epithelium of both the lateral and the median oviducts is similar. The cells are low-columnar to cuboidal in shape and rest on a thin basement membrane. The nuclei of these cells are round, centrally placed and granular. The cytoplasm of these cells is granular also. The cells appear to be active glandular cells. The lumen of the oviduct contains a reticulate arrangement of material. The writer assumes this to be the abundant secretion of the oviduct cells, formed into a net by fixative reagents.

Outside the basement membrane of the oviduct cells are the muscular elements of the oviduct wall. The longitudinal muscles are tight against the basement membrane. The circular muscles are outside the longitudinal muscles. Surrounding the oviducts is the peritoneal sheath. The latter is thin and composed of two thin membranes with scattered, elliptical nuclei.

Riley (1907) states that the cells of the peritoneal sheath, the terminal filament, and the epithelium of the germarium and follicles are of a common origin, but that these somatic cells differ in origin from the sex and nutritive cells.

Kohler (1907) states that cell division occurs by mitosis in the peritoneal epithelium and terminal filament and germarium in the egg tube and that amitotic division occurs in follicular epithelium. The latter is confined to the nuclei and never leads to cell division.

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#### EXPLANATION OF PLATE VIII

Fig. 31. Dorsal view of the nervous system.

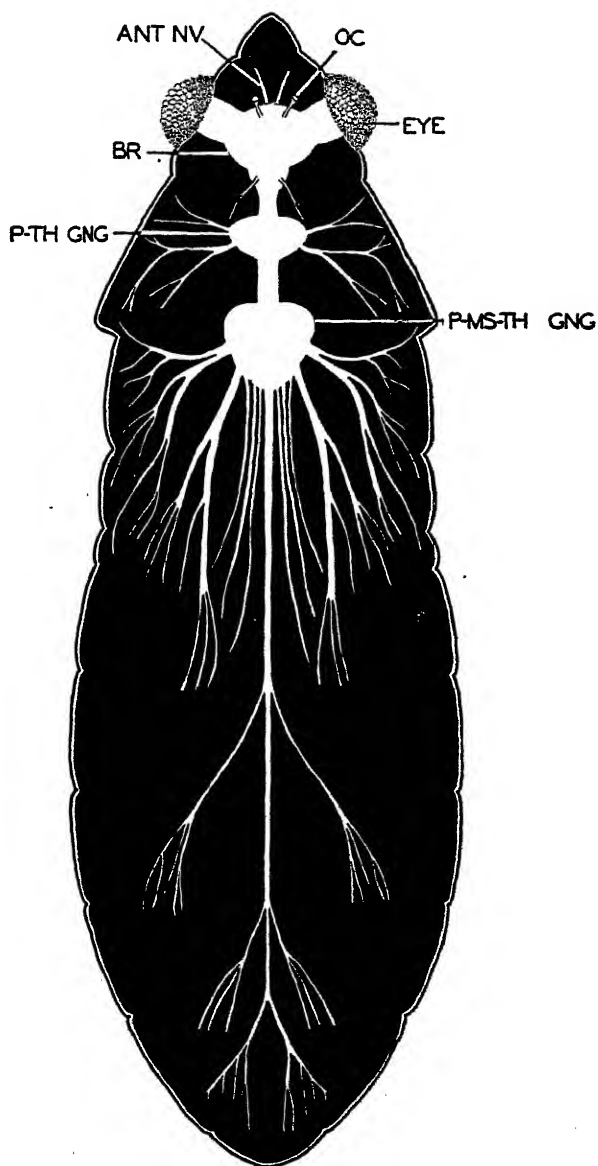


FIG 31



## THE MALE REPRODUCTIVE SYSTEM

The testes of male Hemiptera have six follicles in a single scrotum according to Essig (1942). However, *Leptocoris* has seven follicles in a single scrotum. Baumgartner and Witherspoon (1937) mention the same number of follicles for *Anasa tristis*, a member of the same family, the Coreidae.

The seven follicles or sperm tubes of the box elder bug testes are compacted. The testes are yellow-orange in color and are wedge-shaped. Each follicle of the testis is invested by a peritoneal sheath and the entire testis is inclosed in a similar covering. Like the ovaries of the female box elder bug, each testis is suspended from the dorsal wall of the prothorax by a single suspensory ligament.

The posterior end of each testis attaches to its vas deferens. Each of the two vasa deferentia is dilated midway between the testis and the ductus ejaculatorius (Plate VII, figs. 28, 30). These expansions, which function as a pair of small seminal vesicles, appear as elongate swellings noticeably on the lateral surfaces of the vasa deferentia.

At the junction of the two vasa deferentia and on the dorsal surface of the same, there is a large pyriform organ (Plate VII, figs. 27, 30). The writer assumes the latter to be fused accessory glands since others were not found. Male insects in general have two such glands.

Both the seminal vesicles and the accessory gland are translucent structures. The latter is continuous with the ductus ejaculatorius (Plate VII, fig. 30).

## THE HISTOLOGY OF THE MALE REPRODUCTIVE SYSTEMS

The testes are made up of a series of tubular follicles. The latter are bound together in one plane by a sheath of peritoneum. This grouping of the follicles determines the general shape of the testis.

A follicle consists of a layer of epithelial cells, which lies on a thin basement membrane. The edges of the epithelium join and make a conducting cylinder. A peritoneal membrane invests the follicle and is continuous with the covering of the testis. The follicles of *Leptocoris* are expanded apically and taper to a narrow end at their basal ends. Each follicle in the testis opens separately into the vas deferens.

Snodgrass (1935) differentiates the testicular follicles of insects into four zones in which the sex cells are in different stages of development: first, the germarium, the zone of the spermatogonia; second, the zone of spermatocytes in which cysts of spermatocytes are formed from the spermatogonia; third, the zone of maturation and reduction, in which the spermatids are formed; and fourth, the zone of transformation, in which the mature spermatozoa develop from spermatids.

The above zones are not clearly differentiated in *Leptocoris*. Examples of the different characteristics of some zones are clearly recognizable, however, and some of these will be pointed out later.<sup>3</sup>

The apex of each follicle contains rounded, dark staining cells with large nuclei. These cells are generally grouped together and are

<sup>3</sup>For details regarding the process of spermatogenesis in the coreid *Anasa tristis*, the writer would refer to Baumgartner and Witherspoon (1937), who cite Foot and Strobel (1907) and Paulmier (1899), both of whom describe parts of the same process.

surrounded by a thin membrane. The cells posterior to the apical spermatogonia resemble the latter quite markedly. The writer had difficulty distinguishing between the cells within the follicles other than the spermatids and spermatozoa.

In longitudinal section the early stage spermatids are cuneiform in shape. They are found in the peripheral margins of their enclosing cysts. In a later stage the cytoplasm of the spermatids has decreased, the pointed end of the cell has increased in length and the nucleus has become darker. The pointed portion continues to elongate and the cytoplasm all but disappears around the elongated nucleus.

The resulting spermatozoa have long tails and rod-shaped heads. The sperm cells are packed in bundles in the basal ends of the follicles anterior to the vasa deferentia (Plate VII, fig. 29).

The cuboidal epithelial cells of the basal ends of the follicles resemble the cells of the vas deferens. Each of these epithelia rests on a basement membrane. The nuclei of the cells are oval and the cytoplasm is granular.

The seminal vesicles in the male box elder bug appear to be lateral outpouchings of the vas deferens. The epithelium of both the vas deferens and the seminal vesicle is cuboidal although the cells in the seminal vesicle epithelium are smaller and tend toward columnar shapes.

The seminal vesicle has an abundant muscular layer. The latter is noticeably lacking in the vas deferens. Both circular and longitudinal muscles are present in the wall of the seminal vesicle. There are also scattered cells between the epithelial layers which seem to be connective tissue cells (Plate VII, fig. 28).

A large group of glandular cells is found at the junction of the two vasa deferentia (Plate VII, figs. 27, 30). The writer assumes this mass to be the fused accessory glands. The cells are oval and their nuclei and cytoplasm stain very darkly. The cytoplasm is granular. There is some evidence of secretion in the lumen of the gland at its junction with the ductus ejaculatorius.

The cells of the ductus ejaculatorius are cuboidal and resemble the epithelial elements of the vas deferens.

The testes, vasa deferentia, seminal vesicles and ductus ejaculatorius are enclosed in a thin, peritoneal sheath. The latter membrane is double and has scattered nuclei.

#### THE NERVOUS SYSTEM

The nervous system of insects generally "consists of a mass of nerve tissue, the *brain*, lying above the anterior end of the stomodaeum, and of a *ventral nerve cord*, composed of median segmental ganglia and paired connectives, lying beneath the alimentary canal." (Snodgrass, 1935).

There are some insects, however, in which the structure of the nervous system has become modified. Especially is the latter true of the ventral nerve cord. The ganglia of the latter may be fewer in number or they may be fused. The connectives and commissures may be different or may have disappeared. In some of these cases there is a definite "cephalization" of the nervous elements (Negi, 1934; Nel, 1933; Hamilton, 1931). The ganglia are fused anteriorly into larger masses and the connecting nerve trunks or commissures are absent. The

writer believes the nervous system of the box elder bug to be an outstanding example of this "cephalization" in insects with respect to the nervous system. The bug has a peculiar and picturesque arrangement of ganglia and nerve trunks (Plate VIII).

The nervous system of *Leptocoris* is concentrated in the head and thorax (Plate VIII, fig. 31). It consists of a supraoesophageal ganglion, which occupies the posterior two-thirds of the cranial cavity; a fused suboesophageal ganglion; a transverse, oval ganglion in the anterior portion of the prothoracic cavity, which is connected to the suboesophageal ganglion by two large connectives; and a large, heart-shaped ganglion (referred to as "central ganglion" by Hamilton, 1931 and "pterothoracic ganglion" by Malouf, 1933) which lies in the prothoracic and mesothoracic cavities and is connected to the oval ganglion in the prothoracic cavity by two broad connectives. The heart-shaped ganglion represents the fused elements of most of the ventral nerve chain; it comprises the ganglia of the mesothorax, metathorax, and abdomen.

Two pairs of large nerves extend from the lateral edges of the large, heart-shaped ganglionic mass. Three pairs of smaller nerves extend from its posterior margins. The ganglion terminates in one large nerve trunk which extends caudad along the median line from the posterior edge of the ganglion. There are three pairs of branching nerves which arise from the latter nerve trunk and extend to organs in the abdomen.

The supraoesophageal ganglion occupies the epicranial portion of the head. The main portion consists of two rounded lobes from which stubby, cylindrical optic lobes arise and extend to the eyes. The ocellar pedicels arise from the dorso-anterior regions of this ganglion, one from each bulb of the protocerebrum. A pair of antennal nerves arises from the ventroanterior portion of the supraoesophageal ganglion and extends to the antennae.

The suboesophageal ganglion is directly beneath the supraoesophageal ganglion and is connected to the latter by short circumoesophageal commissures. The compact arrangement of the brain and suboesophageal ganglion leaves little space around the oesophagus and the anterior aorta. This cephalic mass of nerve tissue closely invests the latter organs, so much so that the circumoesophageal commissures are indistinct, and the elements of the latter are lost in the fusion of the brain and the suboesophageal ganglion.

From the anterior portion of the suboesophageal ganglion a pair of nerves arise which innervate the proboscis. Another pair of nerves arise from the dorsoposterior edge of the same ganglion and extend caudolaterally into the neck region.

Two connectives extend posteriorly from the suboesophageal ganglion and connect with the prothoracic ganglion. This oval ganglion lies in the prothoracic cavity. The width of the ganglion is greater than its length and extends transversely. Two nerve trunks arise from the ganglion and extend laterad. The most anterior of these extends to the legs. The posterior trunk innervates the thoracic muscles.

Two cylindrical connectives arise from the posterior margin of the prothoracic ganglion and extend caudad. They join the large, heart-shaped ganglionic mass.

The heart-shaped ganglion ("central ganglion" or "pterothoracic ganglion") is unique. It is the last in the ventral chain and evidently comprises the ganglia of the abdomen and of the last two thoracic segments. From its lateral edges a pair of large nerve trunks arises, bifurcates and extends laterad. These bifurcations branch again and the lateral extensions thus formed innervate the legs and wings.

There is a pair of nerve trunks which arises posterior to the above mentioned pair of nerve trunks. This second pair of large nerve trunks arises on the posterolateral margins of the ganglion and extends caudo-laterad. The trunks bifurcate and the branches innervate regions of the alimentary canal.

In addition to the two large nerve trunks there are three pairs of small nerves which project caudad from the posterior edges of the ganglion. They innervate viscera and muscles.

The ganglionic mass in the prothoracic and mesothoracic cavities terminates in a median nerve trunk. The latter extends down the median line in the abdomen. Three paired main nerve branches arise from this long median nerve trunk. The first pair arises in the third abdominal segment and innervates the viscera in the same region of the abdomen. The second pair of nerves arises in the fifth abdominal segment and innervates the gonads. The median nerve trunk then branches dicotomously and innervates the viscera, sex organs and muscles of the posterior abdomen.

The histological structure of the ganglia consists of an outer coat of ganglionic cells. The nuclei of these cells are varied in size and stain darkly. The inner, whitish-grey, medullary region is composed of an interlacing network of nerve fibers. The nerve trunks and nerves have a similar composition, a lightly-staining fiber mass and a thin cellular covering with a few scattered nuclei.

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COLEOPTERA OR BEETLES EAST OF THE GREAT PLAINS, by J. GORDON EDWARDS. Edwards Brothers, Inc., Ann Arbor, Mich. 181 pages. 1949. Price, \$3.50.

This is a book which everyone interested in beetles will find of considerable value. It contains quite a bit of general information on beetles, a key to the families occurring in the eastern part of the United States, a discussion of each family, and a very complete list of references.

The introductory pages (pp. 1-9) contain information on such subjects as the literature on the Coleoptera, nomenclature and beetle relationships, structural characters of beetles, the use of the key, and a list of the families of beetles (with the number of species and varieties in each family in the United States as well as east of the Mississippi River). The key to families, which covers 42 pages, utilizes a number of characters not used in other beetle keys, and should be easier to use than many of the older keys, particularly for the student. The key is illustrated with 449 original drawings on 23 plates, which are located opposite the pertinent pages of the key. Many of the drawings appear in the plates two or more times, in order that they will be opposite those parts of the key to which they apply. Following the key, each of the 136 families recognized by the author is discussed separately, in alphabetical order. These discussions contain information on the characteristics of the family, means of distinguishing it from similar families, comments on the more important genera and species in the family, often keys to the subdivisions of the family, notes on the life history and characteristics of the larvae, and a list of taxonomic references on the family. These discussions will enable the reader to identify 569 genera and 344 common species. The book concludes with a phylogenetic list of families, a glossary, and an index.

In his delineation of beetle families, the author follows primarily the arrangement in Leng's catalogue; in a few cases, where the adults can be relatively easily separated, he has used other groupings. For example, the Scarabaeidae have been split up, with the Acanthoceridae, Geotrupidae, and Trogidae as separate families; the chrysomelid group is broken up into several families; and the Spondyliidae have been separated from the Cerambycidae because the adults can be readily separated from other cerambycids.

This book is prepared primarily for the student, and the discussions are for the most part very clear and concise. There are a few typographical errors and a few misstatements, but they are in most cases minor in nature. This is an outstanding contribution to entomological literature, and one that should prove very useful for years to come.—D. J. BORROR.

# THE ENTOMOLOGICAL SOCIETY OF AMERICA

## PROCEEDINGS OF THE FORTY-THIRD ANNUAL MEETING

New York City, New York, December 13-16, 1948

The Entomological Society of America held its forty-third annual meeting Monday through Thursday, December 13-16, 1948, in conjunction with the annual meeting of the American Association of Economic Entomologists. Headquarters were at the Hotel New Yorker. Attendance for the combined meetings totaled over 600. Several joint sessions were held with the American Association of Economic Entomologists.

The following sessions of the Society were held:

### Monday, December 13

- 8:30 A. M.—Registration.
- 10:00 A. M.—Joint session. President Knight called the meeting to order and introduced S. A. Rohwer, President of the American Association of Economic Entomologists, who delivered his presidential address.
- 11:00 A. M.—Explanation of exhibits.
- 1:30 P. M.—General Session. President Knight called the meeting to order and appointed the following committees:  
*Nominating Committee:* ALFRED E. EMERSON, J. F. YEAGER, and C. F. W. MUESEBECK, Chairman.  
*Resolutions Committee:* MARION E. SMITH, CURTIS W. SABROSKY, and H. B. HUNGERFORD, Chairman.  
The meeting continued with presentation of papers.

### Tuesday, December 14

- 9:00 A. M.—Joint Session. This consisted of a symposium on the subject "Toxicity of Insecticides to Plants and Animals Other Than Man." S. A. Rohwer acted as chairman.
- 1:30 P. M.—Physiology Section. Presentation of papers. Chairman, J. Franklin Yeager.
- 8:00 P. M.—Annual public address of the Entomological Society of America. Dr. B. V. Travis gave an illustrated lecture on "The Ecology of Alaska."

### Wednesday, December 15

- 9:00 A. M.—Joint Session. This was a panel discussion with invitation papers on the subject "Formulation of Insecticides."
- 9:00 A. M.—Taxonomy Section. Presentation of papers. Mont A. Cazier, Chairman.
- 1:30 P. M.—Joint Session with teaching section of American Association of Economic Entomologists. H. O. Deay, Chairman.
- 1:30 P. M.—Physiology Section. Symposium: The Technology of Physiological Measurements. Robert L. Patton, Chairman.

7:00 P. M.—Entomologists' Banquet. After the banquet, John T. Creighton presented some colored movies on his entomological experiences in Central America.

### Thursday, December 16

9:00 A. M.

#### BUSINESS SESSION

President Knight called the meeting to order and asked for the report of the Secretary.

#### REPORT OF THE SECRETARY

##### *Executive Committee Activities:*

On March 17, President Knight re-appointed DR. P. W. OMAN and DR. S. W. BROMLEY to serve on the Joint Committee on a History of Entomology in relation to the war effort.

DR. P. W. OMAN and the Secretary were appointed to represent the Entomological Society in conference with the Surgeon General at Washington, D. C. The delegates attended a two-day conference at the Pentagon Building.

DR. W. T. M. FORBES and DR. Z. P. METCALF were appointed as official delegates of the Society to the International Zoological Congress in Paris and the International Entomological Congress in Stockholm. DR. ALAN STONE was appointed as delegate from our Society to attend the International Congresses on Tropical Medicine and Malaria.

DR. MAURICE T. JAMES was appointed to the Editorial Board as Managing Editor of the ANNALS.

MR. R. S. FILMER and DR. C. H. CURRAN were appointed as members of the Local Arrangements Committee for the meetings in New York.

The Committee on Insect Physiology submitted the following as members of the Insect Physiology Foundation:

Editor—W. R. HORSFALL.

Editorial Board—LEIGH CHADWICK, December, 1948–December, 1954.

GLENN RICHARDS, December, 1948–December, 1954.

V. G. DETHIER, December, 1948–December, 1952.

J. FRANKLIN YEAGER, December, 1948–December, 1952.

R. L. PATTON, December, 1948–December, 1950.

C. W. KEARNS, December, 1948–December, 1950.

In accordance with this action, the Secretary-Treasurer transmitted to the Editor of the Insect Physiology Foundation the sum of \$1,000 from the Permanent Fund of the Society as per instructions from the preceding business meeting. The seven members of the Insect Physiology Foundation were notified of the action and the Foundation was thereby officially founded.

The sum of \$250 was authorized for expenditures of the Committee on a History of Entomology with the war effort.

Officers of the Physiology Section were appointed as follows: J. FRANKLIN YEAGER, Chairman; ROBERT L. PATTON, Vice-Chairman; and A. GLENN RICHARDS, Secretary. At the same time the Executive Committee set up a Taxonomy Section with the following officers: MONT CAZIER, Chairman; E. G. LINSLEY, Vice-Chairman; and C. W. SABROSKY, Secretary.

Twenty new members were elected by mail ballot.

##### *Annual Executive Committee Meeting:*

This meeting convened on the evening of December 13 with the following members present: H. H. KNIGHT, P. W. OMAN, W. GERTSCH, M. T. JAMES, J. F. YEAGER, H. H. ROSS; and alternates E. O. ESSIG, A. C. HODSON, C. D. MICHENER.

1. Twenty-four new members were elected to the Society.
2. The following members have resigned during the year: C. A. CLARK, R. H. COOPER, J. H. HAWKINS, C. B. HUFFAKER, JOHN W. JOHNSON, K. M. KING, W. H. LARRIMER, H. A. MORGAN, A. W. MORRILL, H. R. PAINTER, W. W. SMITH, CHARLES J. SORENSON, H. D. TATE, W. Y. WATSON, HIRAM C. YOUNG. The following members have been dropped from membership because of failure to pay dues or because they can not be reached: SUNG HIN AU, WILLIAM D. BEDARD, HUGH W. BEDFORD, ERWIN J. EPSTEIN, JOHN A. FLUNO, FLORENCE M. FROST, FREDERICK M. GAIGE, FRED C. HARMSTON, MOHAMMED KAMAL, P. H. MARVIN, M. J. OOSTHUIZEN, EZEKIEL RIVNAY, WILLIAM A. ROSS, M. B. SAILSBURY, ROBERT C. SCHNITZER, A. R. SUMMEROUR, GENEVIEVE WILLIAMS, J. D. WORCHESTER.
3. It was recommended that R. E. SNODGRASS and WILLIAM A. RILEY be elected as Honorary Fellows of the Society.
4. The following were elected as Fellows of the Society: A. N. TISSOT, BERNARD V. TRAVIS, JOHN L. BUYS, EUGENIA MCDANIEL, GEORGE S. TULLOCH.
5. The Society has suffered the loss by death of the following members: J. R. DE LA TORRE BUENO, E. T. CRESSON, JR., A. T. DAMPF, ALFRED FENTON, WILLIAM D. FUNKHOUSER, HUGH GLASGOW, C. L. METCALF, PHIL RAU, C. M. WEED, C. C. WILSON, C. J. WAINWRIGHT. After the reading of the names, the members stood in silence in memory of the departed.
6. The following were elected to fill vacancies of the Editorial Board, and to serve until 1951: A. GLENN RICHARDS, STANLEY FREEBORN, WILLIAM C. COOK.
7. E. S. ROSS and C. E. MICKEL were elected to the Thomas Say Foundation to serve until 1950.
8. It was voted to contribute \$100 to the support of Zoological Record.
9. It was voted that the Historical Committee as at present constituted be placed on a permanent basis, with reappointments to be made by the Executive Committee as needed.
10. In a discussion of the Joint Committee on the Preparation of a History of Entomology in Relation to World War II, it was agreed that the appointment of the committee and the allocation of funds be for the duration of the project.
11. The meeting place for the 1949 meeting was set for Tampa, Florida, December 13-16, in co-operation with the American Association of Economic Entomologists.
12. It was moved that the President be authorized to appoint a Program Committee to assist in planning the annual meetings, if this seems desirable.
13. It was moved that a permanent Taxonomy Section be set up on a parallel basis with the Physiology Section, with the same number of officers, to be appointed annually by the Executive Committee.
14. The following were appointed as officers of the Physiology Section: Chairman, A. GLENN RICHARDS, JR.; Vice-Chairman, LEIGH CHADWICK; Secretary, R. L. PATTON.
15. The following were appointed as officers for the Insect Taxonomy Section: Chairman, C. E. MICKEL; Vice-Chairman, A. N. TISSOT, Secretary, CURTIS SABROSKY.

Respectfully submitted,

HERBERT H. ROSS, *Secretary*.

On motion, the Secretary's Report was adopted as read.

The recommendation for Honorary Fellows was put forward as a motion and a ballot taken. Both members received unanimous approval and were elected.

#### TREASURER'S REPORT

DECEMBER 23, 1947, TO DECEMBER 3, 1948

##### CURRENT FUND

Balance on hand December 23, 1947.....	\$1,751.58
Receipts.....	7,547.66
Total.....	\$9,299.24



## EXPENDITURES

Annals (3 numbers).....	\$4,214.46
Expenses of Secretary-Treasurer's office, including cost of Chicago meetings.....	399.29
Travel expenses and registration fees of delegates.....	58.71
Checks returned, bank charges, and refunds.....	27.80
To Zoological Society of London.....	100.05
To Committee on History of Entomology.....	21.29
Total.....	\$4,821.60
Balance in bank, December 3, 1948.....	4,477.64
Total.....	\$9,299.24

## PERMANENT FUND

Balance on hand December 23, 1947.....	\$4,612.67
Interest.....	10.00
Liberty bond and coupons due.....	52.87
Total.....	\$4,675.54
Withdrawal for Insect Physiology Foundation.....	1,000.00
Balance.....	\$3,675.54

## TOTAL RESOURCES OF SOCIETY

Balance in Current Fund.....	\$4,477.64
Balance in Permanent Fund.....	3,675.54
Total.....	\$8,153.18

Respectfully submitted,

HERBERT H. ROSS, *Treasurer*.

The Treasurer's Report was adopted subject to approval by the Auditing Committee.

## REPORT OF THE MANAGING EDITOR

Because of conditions beyond the control of either my predecessor, Dr. Lindsey, or myself, publication of the numbers of the ANNALS for 1948 has been delayed. The work passed on to me was, of necessity, considerable, and my efforts have been to bring the publication up to date.

We have at present enough accepted manuscripts to publish at least 400 pages. I hope more material than this can be handled during 1949, but I do not want to promise publication for the year in excess of that number. In the future, acceptable manuscripts will be published with exceptions to be noted presently, in the order received. Some deviations from this plan are being made at present, because of our reorganization. For example, some manuscripts have been held up by conditions beyond our control, and it is only fair to the authors to get these into print as soon as possible. Also, in cases in which the author or the institution which he represents pays full cost, publication will be immediate. This does not, however, penalize other authors, since those pages will simply be added to the regular issue.

In New York, I met with the editorial board and agreement was reached on some important matters of policy. We felt that fairness demanded that priority in publication be given to members of the Society, but that we must give consideration, on the one hand, to worthy papers by non-members, and that, on the other, we should have no obligation to accept inferior papers by members. Publication should be sought elsewhere for purely economic papers, most biographical accounts, and for those often quite worthy papers of more local interest. The ANNALS prefers comprehensive descriptive works or those based on experimental research dealing with the more fundamental aspects of insect biology. Unfortunately, our acceptance of long papers is very limited, and the author or his institution will, in the future, have to be asked to pay part of the publication costs for such. It may at times be desirable to set very short papers ahead of

schedule in order to balance the subject matters or to round out the desired number of pages for an issue.

My acceptance of the position of Managing Editor of the ANNALS was made possible by the co-operative attitude and actual encouragement of the State College of Washington. President Wilson Compton, Dean C. C. Todd, and the other administrators not only expressed their approval, but offered material help in the way of supplying me with the necessary stenographic help. I wish also to express my appreciation to my colleagues, especially to Dr. Horace S. Telford and Dr. Morris Rockstein, for material aid during this reorganization period.

The following financial report will close Dr. Lindsey's books. The relatively small amount of material for the remainder of 1948 will be included in next year's report.

#### FINANCIAL STATEMENT

DECEMBER 10, 1947, TO NOVEMBER 1, 1948

##### RECEIPTS

Non-member sales and subscriptions.....	\$ 120.22
From the Columbus office, subscriptions.....	1,358.00
Gorgas Memorial Foundation, printing.....	139.79
From authors for cuts.....	485.51
Bank balance, December 10, 1947.....	3,044.66
Total.....	\$5,148.18

##### DISBURSEMENTS

Engraving.....	\$ 272.19
Postage.....	86.07
Stationery, wrappers, and miscellaneous service and supplies.....	49.97
Refunds on subscriptions.....	9.45
Stenographic and addressograph service.....	291.50
Transferred to Treasurer.....	3,500.00
Bank charges.....	2.06
Transferred to M. T. James.....	936.94
Total.....	\$5,148.18

Respectfully submitted,

MAURICE T. JAMES, *Managing Editor*.

The Report of the Managing Editor was adopted subject to approval by the Auditing Committee.

#### REPORT OF THE TREASURER OF THE THOMAS SAY FOUNDATION

##### RECEIPTS

Balance on hand December 23, 1947.....	\$3,764.86
1947 sales paid in 1948.....	32.10
1948 sales of 22 volumes of 1, 2, and 3.....	88.89
1948 sales of 183 volumes of 4.....	1,120.35
Interest on deposits.....	21.42

Total Receipts.....\$5,027.62

##### EXPENDITURES

Publication of volume 4.....	\$3,293.05
Express charges on books.....	117.34
Express on mailing cartons.....	1.10
Postage on books.....	28.84
Postage on correspondence.....	7.00

Total Expenditures.....\$3,447.33

Balance.....\$1,580.29

Balance in Purdue State Bank.....\$1,584.54

Respectfully submitted,

J. J. DAVIS, *Treasurer*.

Report adopted subject to approval of the Auditing Committee.

## REPORT OF THE AUDITING COMMITTEE

We, the undersigned members of the Auditing Committee, beg to report that we have examined the accounts for the year 1948 of H. H. ROSS, Treasurer of the Society, and have found them to be correct and properly balanced. Accounts of the Managing Editor of the Annals were not examined because they were in process of transfer to the new editor. Accounts of J. J. DAVIS, Treasurer of the Thomas Say Foundation, were not complete at the time the audit was made.

Respectfully submitted,

B. E. MONTGOMERY,

A. M. DEWEY,

WILLIAM R. HORSFALL, *Chairman*.

## REPORT OF THE INSECT PHYSIOLOGY FOUNDATION

The Insect Physiology Foundation was organized according to the recommendation approved at the business meeting of the Society in December, 1947. The function of this foundation is to publish the Journal of Insect Physiology.

The Foundation has received a starting fund of \$1,000 appropriated by the Society. Funds for publication of Volume 1 will be sought before printing begins.

The Editorial Board met in New York in December and approved plans for raising funds for the Journal.

Respectfully submitted,

WILLIAM R. HORSFALL, *Editor*.

On motion, this report was adopted as read.

DR. F. BUTT gave a very entertaining report on the International Entomological Congress at Sweden and announced that the next International Congress will be in Amsterdam, Holland.

## REPORT OF THE JOINT COMMITTEE ON THE PREPARATION OF A HISTORY OF ENTOMOLOGY IN RELATION TO WORLD WAR II

The American Association of Economic Entomologists and the Entomological Society of America authorized the expenditure of not to exceed \$1,000.00 (\$750.00 from the A.A.E.E. and \$250.00 from the E.S.A.) for the services of the editor and other necessary expenditures in connection with the writing of the History. Following the allocation of these funds, the Committee completed arrangements with COL. E. C. CUSHING who was selected as General Editor.

Although much work remains to be done in connection with the reviewing and abstracting of accumulated information, considerable progress has been made in this connection and the actual writing of the History has been under way since approximately mid-year of 1948. It is anticipated that the History will be in final form by the time of the 1949 Annual Meetings of the sponsoring Societies.

STANLEY W. BROMLEY,

RALPH W. BUNN,

EDWARD F. KNIPLING, *Co-Chairman*.

P. W. OMAN, *Chairman*.

This report was read by Dr. Oman who moved its adoption. Motion carried.

## ANNUAL REPORT OF AMERICAN COMMITTEE ON ENTOMOLOGICAL NOMENCLATURE

The outstanding nomenclatural event in 1948 was the meeting of International Commission on Zoological Nomenclature in connection with the Thirteenth International Congress of Zoology in Paris. Notice of some of the most important decisions taken at this meeting has been published in *Science* and elsewhere. In anticipation of this meeting of the Commission, the American Committee on Entomological Nomenclature studied some of the pending cases for which the Commission had published advance notice of applications. The results of this study were communicated to the Commission. In addition, the Committee prepared two applications of its own and submitted them to the Commission. The first of these involved the status of names given to forms of less than sub-specific rank. The second petition related to generic names published after December 31, 1930, without definite unambiguous designation of the type species.

Following the Paris meeting, the Secretary of the International Commission notified the Committee that these matters were considered by the Commission and decisions reached on the various phases of these two problems which had been included in the petitions.

Members were elected or re-elected for 3-year terms to fill vacancies in the Committee as follows: M. A. CAZIER, C. W. SABROSKY, E. G. LINSLEY.

Officers elected for the year 1949 are E. G. LINSLEY, Chairman, and C. D. MICHENER, Secretary.

Respectfully submitted,

E. G. LINSLEY, *Secretary*.

DR. LINSLEY was unable to be present so the report was read by DR. C. W. SABROSKY. The report was adopted as read.

DR. OMAN gave an oral report on the conference attended by himself and the Secretary at the Surgeon General's office. DR. STONE then gave an oral report on the International Congress on Tropical Medicine and Malaria, held in Washington, D. C., and sponsored by the State Department.

It was moved and seconded that the question of abstracts for programs be considered for the next meeting. The question of the financial outlay for this was brought up and the motion passed with the understanding that it was to be construed as a recommendation if the proposition proved feasible.

It was moved and seconded that a membership committee of five members be named to lead a campaign to increase our membership. Motion carried.

#### REPORT OF THE RESOLUTIONS COMMITTEE

1. *Resolved*, that the Society express its appreciation to the Joint Committee for local arrangements: CHARLES L. SMITH, *Chairman*; GEORGE C. BECKER, C. H. CURRAN, HENRY HAYNES, R. S. FILMER; and to the officers of the Society, for their efforts on behalf of this meeting.

2. *Resolved*, that the Society express its gratitude to the management of the Hotel New Yorker for its exceptionally fine spirit of co-operation in making this a successful and enjoyable meeting.

3. *Resolved*, that the Society extend its appreciation to DR. B. V. TRAVIS for his interesting presentation of the Annual Public Address on "The Ecology of Alaska."

4. *Resolved*, that the Society express its sincere regret for the loss through death of several of its members during the past year and that an expression of sympathy be sent to the families of the deceased.

5. *Resolved*, that the Society commend the establishment of the Taxonomy Section and trust that it will continue to be an important feature of the annual meeting.

6. *Resolved*, that the Society express its gratitude to the retiring editor, A. W. LINDSEY, for his years of service to the Society in the editorial work on the ANNALS.

7. *Resolved*, that a letter of appreciation be sent to the State College of Washington and the University of Illinois expressing the appreciation of the Society for clerical help which has been made available for Society officers.

Signed: MARION E. SMITH,  
CURTIS W. SABROSKY,  
H. B. HUNGERFORD, *Chairman*.

## REPORT OF THE NOMINATING COMMITTEE

The Nominating Committee unanimously nominates:

For *President*.....ALVAH PETERSON  
*First Vice-President*.....A. GLENN RICHARDS  
*Second Vice-President*.....PAUL O. RITCHER  
*Secretary-Treasurer*.....H. H. ROSS  
 As members of the *Executive Committee*.....E. G. LINSLEY, O. E. TAUBER  
*Councilors to the American Association for the Advancement of Science:*  
 ALFRED E. EMERSON, 2-year term; J. F. YEAGER, 1-year term  
 C. F. W. MUESEBECK, *Chairman*.

It was moved that the Secretary be instructed to cast a unanimous ballot for these officers. Motion carried.

The meeting then adjourned.

REPORT OF REPRESENTATIVE TO NATIONAL  
RESEARCH COUNCIL

The Division of Biology and Agriculture, National Research Council, held its annual meeting Thursday, May 5, 1949, at the Academy Building in Washington, with Chairman RALPH E. CLELAND presiding. Minutes of the last meeting were approved. DR. D. W. BRONK spoke extemporaneously of the purpose and activities of the Council. Secretary MILTON O. LEE reported that the Agriculture Board had been reconstituted and was due to hold a meeting on May 9. One of its important activities was to be a study of the effect of sanitary regulations on milk quality. The Food and Nutrition Board was due to meet on May 7. The American Institute of Biological Sciences had met on May 5. The Institute had been founded just a year ago with the purpose of advancing biological sciences and their applications to human welfare.

The Institute, it was reported, has under way a project on a handbook of biological data. The first section of the handbook has been contracted for and will be completed in the next few months. This fascicle will deal with blood. Following its completion a decision will be made with regard to the underwriting of the remainder of the projected handbook.

Another project of the Institute of great importance, *viz.*, the work of the Committee on Selective Service, was reported on by DR. L. W. PARR. It was stated that as a result of the labors of this committee and with the complete cooperation of General Hershey's Committee, it now appears definite that biology in its broader aspects will be recognized in the future in any over-all screening program designed to make most effective use of scientific and specialized personnel in time of national emergency. Seventeen biological societies now carry full membership in the Institute and two others have affiliated. These include no entomological societies [which in the opinion of the representative is very unfortunate, H.M.H.]. Information on the A.I.B.S. is available from the National Research Council. There were reports or discussions from various committees of the Division—the Committee on Aero Biology, American Type Culture Collections, Committee on Fellowships, Committee on Advisory Service to the Armed Forces, the Pacific Science Board, Committee on Investigation of Waste Disposal, etc. DR. S. J. DU PLESSIS, University of Stellenbosch, Union of South Africa, addressed the Division on plant research development in South Africa; DR. HARRY KELLEY on problems in Japan; and DR. HAROLD J. COOLIDGE on activities of the Pacific Science Board. The latter report dealt in part with problems with attempts at biological control of the giant African snail and the rhinoceros beetle of coconuts and certain other pests in the Hawaiian Islands.

The Board membership was then constituted into committees, with additional representatives indicated, to review applications for support for foreign travel and study. Two applications came before the Committee on Entomology. The Fulbright Act was discussed by DR. TRYTTEN and the work of the Chemical and Biological Control Division by DR. KERNER. The objectives of the latter include cataloging information from the literature, serving as a screening center, and preparation of reviews that relate structural relationships of chemicals to biological qualities. Its work should be of immense importance to entomology.

Respectfully submitted,

May 16, 1949.

H. M. HARRIS.

## OBITUARIES

THEODORE DRU ALISON COCKERELL, scientist and humanitarian, an honorary fellow of the Society, died in San Diego, California, on January 26, 1948. Though in spite of frail health he had lived a long and extremely fruitful life, he was active to the last.

It is fortunate that Professor Cockerell left us what might serve as an autobiography. I had urged him to prepare such a document, and no doubt others had done so also, as he published in *Bios*<sup>1</sup> a series of fourteen articles entitled "Recollections of a Naturalist." These articles, in addition to giving some of the details of his life, have portrayed in his own words the more essential phases of his philosophy of life and of science.

Theodore Dru Alison Cockerell was born in Norwood, England, August 22, 1866. His second name was given for Henry Dru Drury, a close friend of the Cockerell family and a descendant of the famous entomologist, Dru Drury. In speaking of his childhood Professor Cockerell relates how his father used to bring home all illustrated natural history works he could find, and how eagerly these were read and reread by the young boy. He was a frail child; he has said that he remembered hearing someone say "You must be good to Theo; he will never grow up." His rich background developed in him a very keen interest in natural history. In his youth, he was forced to go to a drier climate for his health, and he spent three years, from 1887 to 1890, in the Wet Mountain Valley of southern Colorado. Apparently cured, he returned to England, where he worked for about a year in the British Museum. During this period the young naturalist developed a close friendship with Alfred Russel Wallace, with whom he had corresponded in Colorado. Probably through the influence of Wallace he was appointed curator of the Public Museum at Kingston, Jamaica, where he assumed duties in June, 1891. The chance to work in the tropics delighted him, and it was there that he began the study of the Coccidae. His health, however, would not permit him to stay. On the invitation of C. H. Tyler Townsend, then professor of entomology at the New Mexico Agricultural College, an exchange of positions was effected. This was, in the long run, fortunate, since it made a teacher of him.

Professor Cockerell has, since that time, remained in the western United States, except for numerous visits and scientific expeditions to various parts of the world. He remained in New Mexico until 1903, and was retained as consulting entomologist for the Agricultural Experiment Station until 1909. From 1900 to 1903 he taught at the New Mexico Highlands University. Then, after a year at Colorado College, as curator of the museum, he began his association with the University of Colorado; this association continued in an active way until his retirement, thirty years later, after which he served in an advisory capacity and was allowed to maintain his office in its previous location. Boulder continued to be his home, though winters were spent, for the most part, elsewhere.

To many men, retirement means more or less the cessation of activity; to Professor Cockerell, it meant the beginning of renewed efforts in scientific investigation. During his years of active teaching, the University had protected his time, so as not to overburden him with teaching duties to the detriment of his research. In 1931, he had joined an expedition, sponsored by the British Museum, into Africa; and now he had time to devote more attention to the bees which had been collected on that expedition. The fauna of the Channel Islands of California also interested him. During the years of World War II, he spent the winters in Palm Springs, California, where he and Mrs. Cockerell were in charge of the Desert Museum. At this time close work was becoming too strenuous for his diminishing eyesight, so in 1943 he had a large part of his collection of exotic bees packed and shipped to the United States National Museum, most of his Nearctic material remaining at the University of Colorado. Nevertheless, he and Mrs. Cockerell spent the winter of 1946-7 at the Escuela Agrícola Panamericana in Honduras where they made a large collection of insects, including more than 200 species of bees. Returning to Boulder, he began to work over these bees, many of which

<sup>1</sup>Vol. 6, pp. 372-385, 1935; vol. 7, pp. 149-155, 205-211, 1936; vol. 8, pp. 12-18, 51-56, 122-127, 193-200, 1937; vol. 9, pp. 21-25, 66-70, 117-124, 1938; vol. 10, pp. 35-41, 99-106, 1939; vol. 11, pp. 33-38, 73-79, 1940.

were new to science. This work once interrupted by illness in Boulder, was resumed in California.

Professor Cockerell's work as a scientist is well known. He was an authority of world-wide reputation on the wild bees. Few specialists have as thorough a grasp of their chosen fields as he did. He also had a wide reputation for his work on fossil insects, scale insects and mealy bugs, and the scales of fishes. He had worked on molluscs, plants, and in fact, all groups of animals, from the Protozoa to the mammals. He has said that the ideal education is a "broad one, sharpened to a fine point." His work, in co-operation with Mrs. Cockerell, on the red sunflower, was a contribution to the science of genetics, and his writings contain many contributions to our knowledge of variation in plants and animals, zoogeography, and evolution. He published two books: "Zoology, a textbook for colleges and universities" (1920) and "Zoology of Colorado" (1927); in addition, he is the author of more than three thousand original articles, book reviews, biographies, and other contributions to his science. He was undoubtedly one of the most prolific scientific writers of our time.

Professor Cockerell was not only a great scientist; he was also a humanitarian, a poet, and a philosopher. As a youth he knew William Morris, the British Socialist leader, and this association considerably influenced his political thinking. In later life, in reply to the question as to whether his views on the subject had changed, he said that he still upheld Morris' idea of the brotherhood of man and of co-operation as the foundation of all progress toward better times, but with the recognition of the impossibility or undesirability of bringing about a sudden change in the organization of society. This philosophy of life was well put into practice. He was constantly giving material aid, as well as inspiration, to many deserving students at the University of Colorado, the Latin American countries he visited, and elsewhere. He campaigned zealously for world peace and for the brotherhood of science. He and Mrs. Cockerell lived simply, with few luxuries; but they gave generously, both in personal aid and financial support, to any cause they considered worthy.

Professor Cockerell published one small volume of verse, and some of his poems were published separately or quoted in his other writings. He did not, however, find poetry as satisfactory a medium of expression as prose. His prose, whether written for the specialist in bees or for the general public, was clear, simple, and precise. He was an eloquent speaker in the sense that he spoke easily, in a plain, straightforward manner, with few embellishments, much anecdotal material, and a humor that had to be heard to be appreciated. He often illustrated talks with blackboard sketches; a few easily made chalk marks would produce a figure of quite characteristic appearance, which was easily recognized for what it was intended to be. His sense of humor showed up very characteristically in these sketches. For example, he would not draw one ant, but, rather, two or more, in single file, because, he would explain, "you never see one ant alone." The big decision of his youth was whether to become an artist or a scientist. It is interesting to speculate what Science's loss might have meant for Art.

Poor health prevented Professor Cockerell from completing his university work, as a medical student, in England. His only degrees were an honorary Doctor of Science from Colorado College, and a similar degree from the University of Denver. His work under such men as Wallace and Morris, together with the rigid course of self-training which he prescribed, certainly must have compensated many times for the lack of formal training. He preferred to be called "professor" rather than "doctor."

Some criticism has been directed against Professor Cockerell's work, particularly that so much of it is in small pieces, with little work of a monographic nature. His habit of publishing many small articles may have been due partly to the difficulty of getting long papers published, partly to the uncertainty of the duration of his life. He did produce some works of monographic nature, however, and he has left an enormous amount of material from which subsequent workers may build monographs. He certainly did not, as too many have done, carry a large part of his life's accomplishments to the grave. He worked for science and for the future generations of scientists, in whom he had great faith. One of my treasures is a copy of Essig's "History of Entomology," given to my wife and me by Professor Cockerell, and inscribed in his handwriting with the following (previously published) poem:

## TO THE YOUNGER GENERATION

"You will see, where we are blind,  
We may seek, but you will find,  
Yet as you hold the golden thread  
Passed on from days of long ago,  
The names of those remembered  
For what they strove to do and know  
May still have power to stir the mind,  
And, passing, leave a gift behind!"

Professor Cockerell is survived by his wife, Wilmatte Porter Cockerell, whom he married during his New Mexico years, and who has been his companion not only in his home but in all his activities. With her visual education program, particularly through the use of teaching moving pictures, she has carried his instruction and research beyond the walls of the University class room.

—M. T. J.

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SOL FELTY LIGHT was born in Elm Mills, Kansas, May 5, 1886. His father was a Presbyterian minister, and his maternal grandfather, J. W. McDill, was United States Senator from Iowa, a member of the U. S. Interstate Commerce Commission and U. S. District Judge. Thus his whole life was motivated by great ability, high ideals, strict honesty, and real responsibility that helped to make him the great teacher and investigator that he was. Little information is available concerning his boyhood. His career began at his graduation with an A.B. from Park College, Parkville, Missouri, in 1908. Following graduation he taught English in the Government Schools in the Philippines from 1908 to 1909; was a teacher in the Manila High School, 1910-1911; and joined the staff of the University of the Philippines as an instructor in 1912. During 1912, also, he made an expedition to Puerto Galero, Island of Mindoro, to study the fauna there. He obtained his M.S. at the University of the Philippines in 1913. During the year 1914-1915 he took a leave of absence to become the Procter fellow in Zoology at Princeton University for which he received another M.S. degree in 1925. Returning to the University of the Philippines he became successively assistant professor (1916-1919), associate professor (1919-1920), professor and chairman of the department of Zoology (1920-1922). He resigned in 1922 to become professor and chairman of the newly founded University of Amoy, China, where he remained until 1924.

In 1920 he accompanied an expedition into the interior of Hainan Island and in 1924 he was a delegate to the Pan-Pacific Food Conservation Conference in Honolulu.

During these years in the Orient he published on zoological subjects including termites. He came to the University of California in 1924 to do graduate work for a Ph.D. and began, under Dr. C. A. Kofoed, to explore the flagellates of termites and to study the termite fauna of western United States. In the spring of 1925 he was appointed associate in zoology at the University of California and later in the same year a University fellow; a lecturer in zoology in the fall of that year; a James M. Geoway Fellow in the spring of 1926; assistant professor of zoology in 1926-27. He received his Ph.D. in 1926. His thesis was on termite flagellates. He was associate professor 1927-1929, and professor of zoology from 1929 until his untimely death by accidental drowning while swimming in Clear Lake, near Clear Lake Lodge, California, June 21, 1947.

On January 1, 1925, he married Mary Nesbit Holdcroft (A.B. Park College) at Redwood City, California. She is at present residing in Alameda, California.

Dr. Light was a remarkable teacher and leader of students as well as an unusually conscientious co-operator. He was always interested in entomology and for many years served as an officer of instruction and advisor of the Division of Entomology and Parasitology. He also served on many of the committees in charge of the qualifying examinations and theses of graduate students in this Division. His thorough understanding and keen interest in research and in teaching problems made him an extremely valuable addition to the entomological program in the College of Agriculture.



He was also interested in many outside activities and during his residence in Berkeley he became an important member, officer, and councilor in the First Congregational Church.

He began publication in 1913 and in all, prepared 70 papers.

In entomology his chief interest was termites, in which group he made notable contributions in the systematics and biology of these remarkable social insects. His discoveries in the parthenogenesis and caste determinations are specially important.

He was a member of the American Association for the Advancement of Science; Entomological Society of America; American Association of Economic Entomologists; Cooper Ornithological Club; Western Society of Naturalists; American Eugenics Society; American Society of Zoologists; American Society of Parasitologists; Society of Experimental Biology and Medicine; La Société Linnéenne de Lyon; China Society of Science and Arts; Royal Asiatic Society (North China Branch); Sigma Xi; Phi Sigma.

Dr. Light's collection of termites was disposed of as follows: A large portion was presented to Dr. A. E. Emerson, University of Chicago, in 1939 and approximately 1,000 specimens, representing many species including paratypes, were presented to the Department of Entomology, California Academy of Sciences, San Francisco, during the same year. He also determined and described species in the collections of the Academy.

The writer is indebted to Dr. Richard M. Eakin, chairman of the Department of Zoology, University of California, and to Miss Frances Weesner, technician in the Department of Zoology for much of the information contained herein.

A complete bibliography of his published works will appear in zoological and other scientific papers.—E. O. ESSIG.

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RUFUS HIRAM PETTIT, B. S., D. Sc., consulting entomologist, Michigan State College, died June 1, 1946. Dr. Pettit was born at Baldwinsville, New York, January 11, 1869. He graduated from Baldwinsville Academy in 1887 and after serving two years as an apprentice in a local machine shop, he entered Cornell University. After one year's college work he served a year as anatomist at Ward's Natural Science Establishment, Rochester, New York, when he returned to the University, where he specialized in entomology, receiving his B.S. in agriculture in 1895.

He was assistant state entomologist of Minnesota 1895-1897 under Dr. Otto Luggar. On January 1, 1897, he was appointed instructor of zoology and assistant in entomology on the Experiment Station, Michigan Agricultural College. Entomology separated from Zoology in 1908 to form a new department with Professor Pettit in charge and acting entomologist on the Experiment Station.

Dr. Pettit was a member of the Lambda Chi Alpha Society, Sigma Xi, and Alpha Zeta; a fellow of the American Association for the Advancement of Science; a charter member of the Entomological Society of America and a fellow since 1939; a life member of the Société Linnéenne de Lyon, France; a member of the American Association of Economic Entomology and of the Entomological Society of Washington.

In 1895 Dr. Pettit was married to Jessa A. Treat of Ithaca, New York, who survives him, together with their two daughters, Mrs. M. S. Nelson, of Indianapolis, Indiana, and Mrs. M. J. Reed of East Lansing, Michigan.—E. I. MCDANIEL.

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RUDOLF WILLIAM GLASER, a member of the Entomological Society of America since 1916 and a fellow since 1941, died suddenly from a heart attack on September 4, 1947, at Princeton, New Jersey. Since 1920 Dr. Glaser has been an associate member of the Rockefeller Institute for Medical Research in the Department of Animal and Plant Pathology. His interests included the physiology, pathology, bacteriology, protozoology and mycology of insects and of late years his work dealt with biochemical studies of the virus and the inclusive bodies of silkworm jaundice. During the war years he tested many animals for susceptibility to the malarial parasite, in an effort to find a host suitable for experimentation. His early work dealt with the wilt disease of the gypsy moth and his early papers are on this subject. Later he published on bacterial disease of caterpillars, the

nature of polyhedral bodies found in insects, the cultivation of bacteriocytes in the German roach and on many related subjects. The nematode parasite of the Japanese beetle was discovered in New Jersey while Dr. Glaser and Dr. Henry Fox were investigating the mortality of grubs in 1929. By 1931 Dr. Glaser had succeeded in cultivating the nematode on an artificial medium. This finally led to the establishment of a parasite laboratory by the New Jersey Department of Agriculture, by which Dr. Glaser was employed as consultant for 17 years.

Dr. Glaser was a prolific worker whose later papers appeared in the *Biological Bulletin*, *Journal of Experimental Zoology*, *Journal of Experimental Medicine*, *Journal of Parasitology*, *Journal of Immunology*, etc. A partial bibliography of 25 of his titles may be found in Edward A. Steinhaus' recent book on "Insect Microbiology" (1946). He was a careful, well trained investigator whose opinions and work were favorably received and appreciated by microbiologists.

Dr. Glaser received his A. B. degree from the University of Michigan in 1911 and from that year until 1913 he was assistant entomologist at Harvard University, from which he received his Sc. D. in 1914. From 1912 to 1920 he was entomologist of the Bureau of Entomology, United States Department of Agriculture. He was born at Cantonsville, Maryland, in 1888, and interment was in Baltimore. At the time of his death he was a member of the American Society of Parasitologists, the Washington Academy of Sciences, the Cambridge Entomological Club, the Michigan Chapter of Sigma Xi and the American Association for the Advancement of Science.—H. B. WEISS.

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HUGH GLASGOW was born in Tennessee, Illinois, November 17, 1884, and died at his home in Geneva, New York, on July 17, 1948, after a long illness. He received the A. B. degree from the University of Illinois in 1908 and the Ph. D. degree in 1913. He served as assistant entomologist at the University of Illinois from 1912-13 and instructor in entomology from 1913-14. He joined the staff of New York Experiment Station, Geneva, in 1914 as an assistant in research in entomology, became an associate in research in 1920, chief in research in 1926, and professor of entomology and chief of the Division of Entomology in 1938, which position he held at the time of his death.

He was a fellow of the American Association for the Advancement of Science and a member of the Entomological Society of America, of the American Association of Economic Entomologists, and of Sigma Xi. In 1944 and 1945 he served as vice-president of the American Association of Economic Entomologists and chairman of the Eastern Branch.

Although his fields of study and interests covered all aspects of economic entomology related to the fruits and vegetables grown in New York State, Doctor Glasgow was probably best known to New York farmers for his work with the pea aphid, the cabbage maggot, and the cherry maggot, all major problems of growers and processors of these important crops. His work along these and other lines attracted nation-wide, in fact world-wide, attention. Since assuming the duties of head of the Division of Entomology, much of his time was occupied with administrative details, but he never lost touch with farmers and their personal problems and until the last participated actively in the Division's research program. A tireless and extremely conscientious worker, Doctor Glasgow commanded the respect and confidence of his professional colleagues, and, most of all, of the farmers of the state, to a degree seldom attained by experiment station scientists.

We are keenly aware of a personal loss of a genial and true friend. Perhaps we can best express the universal feeling on the part of everyone who came in contact with him at any time by saying that always he was acclaimed as a "grand person." We are proud to have known him!

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## BOOK NOTICES

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INSECTS OF HAWAII, by ELWOOD C. ZIMMERMAN. Vol. 1, xx+206 pp., 52 fig.; vol. 2, viii+475 pp., 228 fig.; vol. 3, vii+255 pp., 110 fig.; vol. 4, vii+268 pp., 92 fig.; vol. 5, vii+464 pp., 238 fig. University of Hawaii Press. 1948.

It is expected that the complete work will involve 12 to 15 volumes; but since there will evidently be a rather long period of time between the publication of volumes 1 to 5 and the appearance of the succeeding volumes it seems appropriate to attempt an appraisal of the parts that have been issued.

In these years of increasingly narrow specialization in insect taxonomy it is almost incredible that one man should attempt to encompass even so large a field as is represented by these first five volumes and still hope to offer a reasonably critical treatment of each group. Zimmerman has done this, however, and he has been amazingly successful. He has not been inhibited by various practices that have become more or less standard with specialists in individual groups, and for that reason he has brought to the subject fresh approaches and original views. To be sure certain portions are somewhat less thoroughly done than others and, of course, mistakes have been made; but no part of the series published thus far can be considered a superficial treatment.

A sharp observer, a skilled taxonomist, and a worker who drives himself relentlessly, Zimmerman has made the most of his many years in the Islands and has acquired a broad understanding of insular faunas in general. This has been of immense help to him in the preparation of the present work. Moreover, he has availed himself freely of the advice and guidance of others with long experience in Hawaii, particularly C. Montague Cook, Otto H. Swezey, C. E. Pemberton, F. X. Williams, and R. H. Van Zwaluwenburg; and he has also called upon specialists in various groups for help with specific problems.

In Volume 1, which is introductory, the author has capably reviewed the geological history of Hawaii, has presented analyses of the biota, including a tabular summary of the endemic Hawaiian insects and a discussion of the flora with a summary of the Hawaiian plants, and has given an interesting account of the development of the endemic fauna.

The remaining four volumes are technical, taxonomic treatments of certain insect groups. Volume 2 covers the Apterygota, represented in Hawaii by only a few forms: Embioptera, of which Hawaii has only one species; Orthoptera; Isoptera; Dermaptera; Zoraptera (a single species); Corrodentia; Mallophaga; Anoplura; Odonata, and Thysanoptera. Many of the illustrations are taken from other publications but there are numerous good original photographs and drawings. Keys to the genera are given, and also keys to the species of most of the larger genera; some of these, particularly for certain large endemic genera of Orthoptera, (e.g., *Paratrigonidium*) are rather weak and will be difficult to use successfully; but on the whole the keys, supported by illustrations and by notes on habitat, hosts, and behavior, will permit recognition of individual forms.

Volume 3 is devoted to the Heteroptera. The nomenclature has been brought up to date; and many species heretofore known only from inadequate descriptions are illustrated, some of them from the holotypes in the British Museum. These illustrations will be of much value in future studies of such families as the Nabidae and Miridae, the Hawaiian species of which are numerous and still largely undescribed.

Volume 4, on Homoptera: Auchenorrhyncha, makes it possible for workers to identify the Hawaiian leafhopper fauna with reasonable accuracy, and it provides an excellent starting point for critical taxonomic studies in these groups. Essentially the treatment is synoptic, but some parts are also revisional in that certain erroneous generic placements have been corrected. On the whole the subfamily definitions and allocations of the genera in these subfamilies follow the generally accepted arrangements. It is noted, however, that Typhlocybinae is used for the group properly called Cicadellinae, a course which would leave the family Cicadellidae without a typical subfamily.

Volume 5 deals with the sternorhynchous Homoptera, including the psyllids, aphids, and coccids. The first three of these groups are briefly treated since the Hawaiian representation is very small. There are, however, particularly in the section on aphids, some original illustrations, drawn by Frieda Abernathy, that are excellent. The scale insects and mealybugs of Hawaii have received a good deal of serious attention in the past; furthermore, in developing the section on the Coccoidea, Zimmerman obtained excellent cooperation from the outstanding American specialists in this group. He was thus enabled to give a more thorough treatment than was done for most of the other groups covered in these five volumes. With its numerous, often double-page, anatomical figures (prepared by Professor Ferris after the pattern followed in his *Atlas*) and the detailed discussions of both the taxonomic and ecological relationships of the species, this section appears to approach the ideal for a restricted faunistic study and it will have utility far beyond the limits of the Hawaiian Islands.

Altogether, approximately 5,000 species of insects have been recorded from the Hawaiian Islands. About 1,100 of these are treated in Volumes 1 to 5 of "Insects of Hawaii." Because our knowledge of them is still very fragmentary, some of the groups can only be covered rather sketchily; but for all groups treated this work should be of immediate value because it brings together references to all the described Hawaiian species for which, in the past, it has been necessary to consult numerous publications, some of them not readily available in most libraries. The author has covered this literature thoroughly and has given a list of the literature consulted at the end of each ordinal treatment. The whole work has been planned and executed with care; it is well printed on paper of good quality, and it is commendable in a high degree. It is a work that will be immensely and increasingly useful to serious students everywhere who attempt to understand the intricacies of insect classification and distribution.—C. F. W. MUESEBECK.

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HOW TO KNOW THE IMMATURE INSECTS, by H. F. CHU, vi + 234 pages, 631 figures. Wm. C. Brown Company, Dubuque, Iowa. 1949. Price, \$2.00, spiral binding; \$3.00, cloth.

The appearance of a second taxonomic manual of immature insects within a few months' time is noteworthy. Dr. Chu's work follows the pictorial key style of the other nature manuals edited by H. E. Jaques, and students who have found this plan useful should have equal appreciation of the present book. It is extremely convenient to have each important step in the key illustrated and to have new technical terms explained by illustrations at the point where they are mentioned, without requiring the user to consult figure or plate on another page. However, this involves repetition of figures and requires publication of a greater number of them. Some of the illustrations are hardly acceptable, although most of them well serve the purpose for which they were intended.

The first part of the book (pages 1-28) briefly discusses metamorphosis, the value of the study of immature insects, the various stages and types, and the technique of collecting, preserving, and rearing. The body of the work (pages 28-216) is devoted to the keys, with some of the more important references (pages 217-223) and an index and pictured glossary (pages 224-234).

In general, one does not find much that is new in the parts devoted to the Holometabola. These keys are mainly adaptations from well-known works such as those of Malloch, Yuasa, Mosher, Böving and Craighead, and Van Ermen. It is, nevertheless, a great advantage to have this material brought together under one cover, along with keys to other groups on which there is no standard treatment. A few errors have been made either typographically or in transcribing the keys; for instance, on page 86, couplet 31b should lead to "40" instead of "42", and on page 91 couplet 42b should lead to "66" instead of "67." The number of such errors, however, appears to be small.

This work will not replace that of Peterson, the first part of which was reviewed in the March, 1949, *ANNALS*. On the other hand, it should find its own place alongside that more ambitious work, as has been the case with the other manuals of this series.—M. T. J.

REVISTA DEL INSTITUTO DE SALUBRIDAD Y ENFERMEDADES TROPICALES. Secretaria de Salubridad y Enfermedades Tropicales. México, D. F., México.

This journal should not be overlooked by students of medical entomology. It is published quarterly, about 400 pages constituting an annual volume, and is devoted to articles by workers in the Institute, or by others if the articles deal with problems related to those studied at the Institute. Of the articles in volume 9, 1948, seventeen, with a total of 148 pages, deal with medical entomology and related subjects. These are concerned with malaria (3 articles, 24 pages), *Anopheles* taxonomy and rearing (3 articles, 19 pages), mosquito taxonomy other than *Anopheles* (1 article, 4 pages), taxonomy of the Simuliidae (3 articles, 64 pages), onchocerciasis and simuliid control (3 articles, 14 pages), taxonomy of the Trombiculidae (1 article, 10 pages), murine typhus (1 article, 3 pages), phototropism in mosquito larvae poisoned by DDT (1 article, 3 pages), and larvicidal action of DDD (1 article, 7 pages).—M. T. J.

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A CENTURY OF ENTOMOLOGY IN THE PACIFIC NORTHWEST, by MELVILLE H. HATCH. v + 43 pages, 9 plates. University of Washington Press, Seattle. 1949. Price, \$1.50.

This little book is not of the magnitude of the contributions to the study of the history of entomology by Howard, Weiss, Essig, and Osborn; yet it merits serious consideration along with those important works. It is in a way a kaleidoscopic sketch of those individuals who have entered into the making of North-western Entomology, from the ornithologist Dr. John Kirk Townsend, who first collected insects in the area, to the present day.

Dr. Hatch divides the history into four periods, each treated in one chapter: the period of itinerant collectors, the period of resident collectors, the period of established laboratories (1890 to 1930), and the present day (since 1930). A short chapter is devoted to private and institutional collections. The twelve pages of citations include a number of references to arthropod faunistics of the Pacific Northwest, and the usefulness of this list is increased by a taxonomic index following it. The plates are devoted to portraits and photographs of J. M. Aldrich, A. L. Melander, G. W. Taylor, R. C. Treherne, A. L. Lovett, E. H. Blackmore, Ralph Hopping, Orson Bennett Johnson, and Trevor Kincaid.

The material in this work is highly condensed and meaty; in fact, it is regrettable that so much has to be omitted. There is too little space for a discussion of the contributions of the makers of Northwestern Entomology, particularly in the applied fields. The omission of some important names (for example, A. S. Spuler) will be noticed.

By what is obviously a typographical error, the collection of the State College of Washington is said to contain only 45,000 specimens, about one fifth its present size. The 1943 estimate, upon which this figure was probably based, was 145,000.

—M.T.J.

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KÄFER UND PILZE, by OTTO SCHEERPELTZ and KARL HOFER. 351 pages, 19 text figures, 9 plates (8 colored). Verlag für Jugend und Volk, Wien. Price \$5.40.

The appearance of a well-conceived and well-executed book on a specialized field of biology is always news. When the book combines two widely separated fields, is the result of new and extensive researches, and is produced under high standards of publication, the reviewer may use up all his superlatives. And yet, for all this, such a book is likely to interest relatively few biologists, because of its specialization. If it is so written as to give up readily the implications of its conclusions for other fields, it may appeal more widely.

For such a book to be published in the Austria of 1948, with the myriad difficulties surrounding any such venture in post-war times, seems to be a miracle, especially to us in America, where, in spite of relative prosperity, such a thing would not be thought possible.

The present book is a study of the fungi of the forests around Vienna and the beetles that live in association with them. It is an attempt to assemble accurate data concerning the interrelations of these two biological fields.

Drs. Scheerpeltz and Höfler commenced work on this project in 1946, when 35 excursions were made in the vicinity of Vienna to collect fungi and their beetle associates. The careful identification of each fungus, as well as of its associated beetles, is one of the prime contributions of the work. The results of each excursion are given in detail, with a list of the beetle specimens found with each species of fungus.

This is followed by a systematic treatment of the beetles, listing the host fungus for each, with notes on occurrence and distribution. Twenty-two families of beetles (consisting of 176 species represented by 4,041 specimens) are cited from over 118 species of fungus. Of these 176 species, 109 are Staphylinidae.

Ecological analyses are made in several ways, including discussion of biotopes, the pH, smell, and taste of the fungi (chemically), the sociology of the inhabitants, and the succession of visitors. In this section particularly, frequent reference is made to the work of others.

A bibliography of nearly 150 titles provides a major source of information on the entire subject of insect-habitants of fungi, including systematic, geographic, ecologic, morphologic, and physiologic papers.

As if the assembly and publication of this detailed and analytical report was not sufficient for their energies, the authors have illustrated the book with two maps, one graph, 19 text figures containing 55 drawings, one plate of 10 figures showing beetle habitus as well as distinguishing characters, and 8 colored plates. The latter show 48 species of beetles and 24 species of fungus.

The systematic section reflects the lifelong interest of Dr. Scheerpeltz in staphylinid beetles. Keys for determination of the Central European species of six genera are given. In addition eight new species and one new subgenus are described (seven species in *Atheta*, one in *Oxyptoda*; the subgenus *Leptharthrophæna* in *Gyrophæna*).

The book is remarkably free from typographical errors and other mechanical defects. Only one is noted, that of the new subgenus *Leptharthrophæna* (pages 164 and 166) as *Lapharthrophæna* (page 170).

This is one of the most satisfying books of its kind ever to come to our attention.—R. E. BLACKWELDER.

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A STUDY OF THE PTILINUM AND PTILINAL  
MUSCULATURE OF THE POMACE FLY,  
*DROSOPHILA MELANOGASTER* MEIGEN<sup>1</sup>

(Diptera, Drosophilidae)

E. LAURENCE ATKINS, JR.

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INTRODUCTION

The pomace fly, *Drosophila melanogaster* Meigen, is one of the flies of the group Cyclorrhapha and suborder Schizophora which in the pupal stage possesses on the cephalic aspect of the head an extensive membranous organ or frontal sac, the ptilinum. It serves by its alternate distension and contraction to rupture the puparium and assist in the emergence of the imago. After emergence the ptilinum is permanently retracted as an invagination within the head capsule. Although the function of the ptilinum has been known since it was first described by Réaumur (1738), it is not known, to the author's knowledge, whether the failure of the adults to emerge from the puparia, in lethal flies, is dependent upon the failure of the ptilinum to function or upon some other cause. This research was instigated to determine the role of the ptilinum and attached muscles in the emergence of the normal flies. The author hopes to make a study of the lethal flies at a later time.

The investigation was conducted at the suggestion of Dr. W. M. Luce, Assistant Professor of Zoology at the University of Illinois who has assisted throughout the work. The author wishes to express his sincere thanks to Professor Luce for his encouragement and help and to Dr. William P. Hayes, Professor of Entomology, for his critical reading of the manuscript.

REVIEW OF THE LITERATURE

Very little work has been done on the function, muscles, and histology of the ptilinum of the ptilinal-bearing Diptera since Réaumur's original description. Most of this work has been on the ptilinum of the blow fly, *Calliphora erythrocephala* (Meigen).

<sup>1</sup>Contribution No. 281 from the Department of Entomology of the University of Illinois.



Knab (1911) gave a short review of the literature concerning the emergence of cyclorrhaphous flies from their puparia. According to this review, Joly (1846) pointed out that the inflation of the ptilinum took place by blood-pressure and not by air-pressure as Réaumur suggested in 1738. Künckel d'Herculais (1875) stated that an apparent ptilinal mechanism was to be found in the syrphids (*Syrphus*, *Volucella*, and *Eristalis*), but he was wrong in that this was not a true ptilinum but was caused by the expansion of the genal areas during eclosion—a phenomenon found also in *D. melanogaster*. Laing (1935) states in her review of the literature that Lowne (1890–92) was the only one before her who gave an account of the muscle supply of the ptilinum. Both Lowne and Laing worked on the blow fly.

Wahl (1915) and Laing (*l.c.*) are the only ones who have discussed the development of the ptilinum. Wahl (*l.c.*) stated that the meso-caudal portion of the frontal sac migrates to the anterior end of the pupa and later becomes reinvaginated, becoming the ptilinum. The frontal sac is the cephalic portion which bears the imaginal discs of the antennae and compound eyes which, when invaginated, form the head of the imago. Laing further elaborated on the development of the ptilinum in her work.

Robertson (1936) thoroughly studied the mechanism of metamorphosis of the larva during the third, fourth (or prepupal) instars, and the pupal stage. He stated that during the quiescent fourth larval instar the larva becomes loosened from the puparium, and a large gaseous bubble is formed within the body during this prepupal period. At the end of this stadium, it pupates, shedding the prepupal or fourth instar cuticle. The gas bubble is used to separate the cuticle from its hypodermis. Practically all of the tissues undergo change and are replaced by imaginal structures derived from specialized cells, the imaginal buds. Some of the muscles persist longer than the general mass and perform special functions in the pupa.

#### MATERIAL AND TECHNIQUE

*Material.*—The parent flies<sup>2</sup> were placed in four dram vials containing food and allowed to remain for four hours to enable the females to deposit all eggs which might have been held in the oviducts until a suitable place for oviposition was available. In this way eggs of about the same degree of development were obtained for study. The parent flies were then transferred to fresh vials of food and allowed to oviposit for one hour and were again transferred to fresh vials. These eggs were then allowed to hatch and to develop until the larvae and pupae were removed from the vials to be killed and fixed. The adults were removed as they emerged and placed in groups of 10 to 20 in vials with fresh food and were killed when the desired ages were reached. The food consisted of water, agar-agar, dehydrated yeast, corn meal, and molasses. The flies were raised in a controlled temperature room at a constant temperature of 21.5° C. and 69 percent relative humidity.

<sup>2</sup>The flies used in this study are from the wildtype +1119.1 known as "Luce's Wild Stock," which has been maintained in the laboratories of the University of Illinois for over thirty years.

*Technique.*—The larvae were killed, fixed, and sectioned, at 120 hours after hatching, which was 12 to 14 hours before pupation; at 126 hours, after the larvae had crawled up out of the food to pupate; at 134 hours, at which time the anterior spiracles had everted, and the flies had entered the prepupal period which lasted about 30 hours at 21–22° C.; at 144 hours; at 158 hours which was just before the commencement of the true pupal stage when the imaginal buds of the head become everted; and at 24 hour periods thereafter until the emergence of the adults, which occurred at approximately 102 hours after pupation.

The adults were killed, fixed, and sectioned at periods of 30 minutes after emergence; 2 hours; 12 hours; 24 hours; and then at 24 hour periods up to 10 days after emergence. No flies over 10 days old were studied.

The specimens were killed by immersion in boiling water for 5 minutes, fixed for from 12 to 24 hours in a cold solution of a modified Bouin's solution<sup>3</sup> which imparts a yellow stain which is useful later in

1 per cent picric acid in 95 per cent alcohol.....	180 cc.
Chloroform.....	30 cc.
Glacial acetic acid.....	15 cc.

orientating specimens in the paraffin blocks, dehydrated in ascending grades of alcohol beginning at 70 percent for two hours duration to absolute, 50–50 solution of absolute alcohol-cedarwood oil,<sup>4</sup> two changes of cedarwood oil, two changes of melted paraffin, and embedded in paraffin. Sections were cut at 10 microns thickness and fixed to slides with Haupt's adhesive and anhydriated in descending grades of alcohol to distilled water. The picric acid was removed by lithium carbonate, a saturated solution, in 70 percent alcohol. Mordanting was accomplished with a 5 percent solution of iron-alum, washed, and stained 12 hours with Heidenhain's hematoxylin and destained with a 1 percent solution of iron-alum to the desired intensity. Then they were rehydrated and mounted in balsam.

Dissections of the heads of imagines in glycerine under a binocular microscope, the ptilinum distended, gave valuable preparations for the study of the musculature.

#### DEVELOPMENT OF THE PTILINUM

In larvae 120 hours old<sup>5</sup> the frontal sac, which represents the developing imaginal head complex, that is, the compound eyes, the antennae, and the ptilinum, is quite small and not as yet everted. Chen (1929) gives an accurate description and explanation of the cephalic complex in the larval stages, but he and other authors have failed to trace the development of the ptilinum. The ptilinum cannot be actually pointed out until after the two lateral lobes of the frontal

<sup>3</sup>The formalin in Bouin's solution was replaced with chloroform to prevent the hardening effect of formalin upon chitin. The modified fixing solution formula used was as follows:

<sup>4</sup>Cedarwood oil was substituted for xylol to prevent excess hardening of the chitin previous to sectioning (Eltringham, 1930).

<sup>5</sup>Specimens reared at 21.5° C. and 69 percent relative humidity and upon the food used in this study showed an extended larval period of 30 hours and an extended pupal period of 6 hours over those reared by other authors at 25° C.

sac have fused mesally and have become hollow. The frontal sac continues to become enlarged in 126 hour larvae which have crawled up on the sides of the vials and have become quiescent prior to pupation.

At the time of pupation (when the anterior spiracles have become evaginated from the puparium) the frontal sac has become quite enlarged, and the ptilinal region of 6-hour prepupae appears as a vague thickened cellular area above the differentiated antennae. In 16-hour pupae the antennal fossa is evident as a separate area.

Somewhere between the twenty-fourth and thirtieth hours at 21.5° C. the developing pupa separates from the fourth larval integument, and the forcible eversion of the frontal sac takes place, indicating the commencement of the true pupal stage. Some of the muscle strands are just beginning to become evident as very obscure thin strands of tissue.

It is not until around 54 hours after pupation that the ptilinum is plainly apparent as a definite spinuleless region of dividing cells. The ptilinal area at this time is partially invaginated in most specimens. The transverse-vertex muscle is now clearly visible on the vertex, and the transverse-ptilinal muscle is also just forming. The post-occipital-proboscal muscle and the ptilino-pharyngeal muscles are just forming. In the 78-hour pupae the ptilinum has continued to gradually become almost fully invaginated with its continual development, and by this time the ptilinum already bears cuticular spinules. The developing muscles, attached to its surface, are represented by linear chains of nuclei surrounded by a small amount of unstriated cytoplasm.

At 102 hours the ptilinum is usually fully evaginated and pulsations are often apparent. As the surface of the ptilinum increases, its thickness gradually decreases, the increased area of the ptilinal membrane accommodating itself by becoming enfolded and crumpled as it invaginates within the head. At this time the organ is completely developed, and the cuticle has become greatly thickened, and the epidermis has been reduced to an attenuated layer.

#### THE PTILINUM AND PTILINAL MUSCULATURE

The bulk of the ptilinal membrane lies between the mesocaudal limits of the vertex and the bases of the antennae and lunule. However, a narrower extension of the ptilinal membrane also passes ventrad on each side between the fronto-clypeus and the genae, the full length of the ptilinal or frontal suture. After emergence from the puparium is effected, the whole region of the ptilinum is permanently invaginated within the head capsule, leaving as external evidence of its presence only a narrow invagination representing the  $\cap$ -shaped suture setting off the fronto-clypeus from the vertex and genae. The lunule is located on the fronto-clypeus just dorsad of the points of insertion of the antennae. It is a small crescent-shaped area of thickened cuticle forming the dorsal margin of the fronto-clypeus. It is naked and appears on the inflated ptilinum as a clear area located mesad above the antennae.

The structure of the ptilinum in the newly emerged imago is somewhat similar to the integument of the genae, vertex, and fronto-clypeus with which it is continuous. The major difference is that the spinules

which cover the surface of the ptilinal membrane are broadened at their bases and are not surrounded by a sclerotized ring as are the slender setae of the ectal surfaces of the head capsule. The spinules are about the same length as these setae but are somewhat stouter. All of the spinules of the ptilinal organ are of the same shape as is true in *Calliphora* as described by Laing. The ptilinum consists of a layer of cuticle 20 to 25 microns in thickness without pigment and staining lightly with the stain and is covered with spinules regularly arranged, is not stained with Heidenhain's haematoxylin. They have an average width at their bases of 20 microns and a height of 20 microns. The whole is secreted by a syncytial epidermis.

On the entral surface of the ptilinal membrane are the insertions of certain muscles, all of which function only as retractors of the organ during and after emergence of the imago. These muscles are as follows:

*Transverse-ptilinal muscle* (figs. 4 and 7, *t.p.*).—These are the "compressors" of Lowne (*l.c.*). The fibers extend horizontally across the cavity caudad of the ptilinum and have a dorso-ventral attachment with the membrane near the adjacent laterocaudal projections of the vertex. This bundle of muscle fibers is attached in a central position on the broad region of the ptilinal membrane and is about 50 microns deep and 20 microns wide. When the ptilinum is invaginated, the muscle forms a compact mass over its ental surface. It functions as a compressor of the ptilinal membrane after each distension pulsation and to permanently invaginate the ptilinal membrane after emergence. The transverse-ptilinal muscle appears to be just forming in 30-hour pupae at 21.5° C. and 69 percent relative humidity and is functional in 54-hour pupae. It is retained until after emergence but is completely lost before the imago is 12 hours old. Only traces of this muscle are to be found in many of the imagines two hours old.

*Ptilino-pharyngeal muscle* (fig. 8, *p.p.*).—This muscle arises from the cornua of the basipharynx and holds the oesophagus between the cornua since the muscle is an unbroken sheet up to the point where it forks to attach to the cornua or "fulcrum" of Laing. It has a wide base of insertion on the most anterior region of the inflated ptilinum in a narrow band of wide lateral extent. Laing (*l.c.*) terms this muscle the "ptilino-oesophageal muscle," and according to her these are the fibers termed "retractors of the fulcrum" by Lowne, "retractors of the oesophagus" by Graham-Smith (1930), "and muscle ptilino-pharyngien" or "m. retractor ptiline" by Mercier and Villeneuve (1925). The author's own observations corroborate the opinions of Laing and of Mercier and Villeneuve in indicating that this muscle plays an important role in the retraction of the ptilinum. Mercier and Villeneuve further supposed that after invagination of the ptilinum the ptilino-pharyngeal muscle played the role of pharyngeal dilator. Since, however, from sections of imagines over 12 hours old all traces of this muscle are absent, the present author agrees with Laing's work on *Calliphora* that the only function of the ptilino-pharyngeal muscle is the retraction of the ptilinum. The ptilino-pharyngeal muscle was first found in 30-hour pupae (fig. 2, *p.p.*) and was lost 12 hours after emergence.

*Ptilino-tentorial muscles* (fig. 9, *p.t.m.*).—These are paired muscles which are similar to those found by Laing in *Calliphora*. They arise

from short tendons which are attached to the body of the tentorium at its lateral junction with the border of the occipital foramen (fig. 10, *p.t.m.*). They are inserted on the ptilinum at each side dorso-laterally as a narrow band immediately in front of the line of demarcation between the vertex and the ptilinum. Laing (*l.c.*) states that these muscles are homologous with Lowne's large fan-shaped retractors and aid in retracting and invaginating the ptilinum. In 78-hour pupae the ptilino-tentorial muscles are just forming and persist until they are completely dissipated in 20-hour imagines.

#### THE MUSCULATURE ASSOCIATED WITH THE PTILINUM

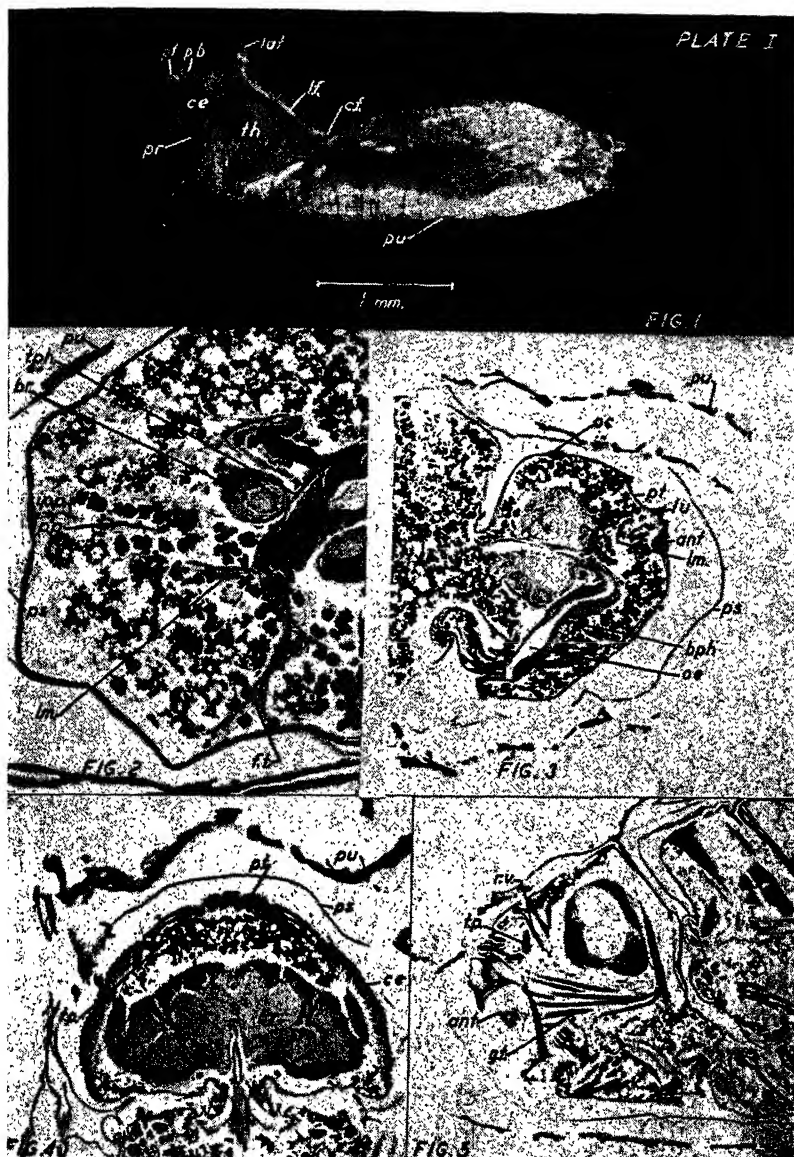
Although not inserted on the ptilinal membrane, there are in the head capsule seven other groups of muscle fibers which apparently are associated with the ptilinum and other parts of the head during emergence. These are as follows:

*Geno-tentorial muscles* (figs. 5, 6, 10, and 11, *g.t.*).—These muscle-fibers arise from the same tendons as the ptilino-tentorial muscles (fig. 10, *p.t.m.*) and also from the occipital sclerotized thickenings which mark off the occipital sclerites. They are inserted over a wide dorsoventral area on each gena between the compound eyes and the frontal suture. According to Laing the contraction of these muscles results in the approximation of the genal and occipital regions and when haemolymph is being withdrawn into the abdomen, returns the shape of the head to normal. When the head is distended with haemolymph, the contraction of these muscles appears to result in the flattening of the genae. Haemolymph is thus forced forward into the ptilinum which is thereby rendered more turgid and helps in rupturing the puparium. These muscles are found forming in 54-hour pupae and have almost disappeared in 24-hour imagines.

*Fronto-tentorial muscles* (figs. 6, 10, and 11, *f.t.*).—This pair of muscles arises from the same tendons of the tentorium and occipital sclerites though more centrally than the geno-tentorial muscles (figs. 6, 10, and 11, *g.t.*), and are inserted in large dorsoventral groups on the

#### ABBREVIATIONS USED ON PLATES

ant....antenna	pb....boundary between ptilinum and vertex
bph....basipharynx	p.p....ptilino-pharyngeal muscle
br....brain; supra- and sub-oesophageal ganglia	pr....proboscis
ce....compound eye	ps....pupal sheath; fourth larval integument
c.f....circular fissure of puparium	pt....ptilinum
cr....cornua	p.t.m. ptilino-tentorial muscles
f.t....fronto-tentorial muscle	pu....puparium
g.t....geno-tentorial muscle	r.a....oculo-antennal muscles—retractors of the antennae
i.p.p....insertion of ptilino-pharyngeal muscle on ptilinum	r.v....fronto-pharyngeal muscles—retractors of the vertex
lat....larval anterior spiracle	t....tentorium
l.f....longitudinal fissure of puparium	th....thorax
l.m....lunular muscle	t.p....transverse-ptilinal muscle
lu....lunule	t.ph....tentorio-pharyngeal muscle
m.x.p....maxillary palpus	t.v....transverse-vertex muscles
oc....ocellus	
oe....oesophagus	



#### EXPLANATION OF PLATE I

FIG. 1. Microphotograph of lateral aspect of the pomace fly, *Drosophila melanogaster* Meigen, in the act of emergence. FIG. 2. Microphotograph of sagittal section of head of 30-hour pupa showing oesophagus passing through the supra- and sub-oesophageal ganglia of brain. FIG. 3. Microphotograph of sagittal section of head of 54-hour pupa. FIG. 4. Microphotograph of dorso-ventral section of head of 78-hour pupa. FIG. 5. Microphotograph of sagittal section of head of 102-hour pupa.

lateral margins of the fronto-clypeus. They are not concentrated in one area just below the bases of the antennae in *D. melanogaster* as Laing has described for *Calliphora*. Contraction of these muscles also results in diminution of the volume of the head as do the genotensorial muscles. These muscles are found forming in 30-hour pupae (fig. 2, *f.t.*) and persist until they disappear shortly after the seventy-second hour in imagines.

*Transverse-vertex muscles* (fig. 8, *t.v.*).—This muscular layer lies underneath the integument of the vertex immediately caudad of the greatly thickened mesal part of the frontal suture and extending transversely between the compound eyes. The contraction of this muscle layer diminishes the volume of the head. This muscle appears first in 30-hour pupae and is almost entirely gone in two-hour imagines.

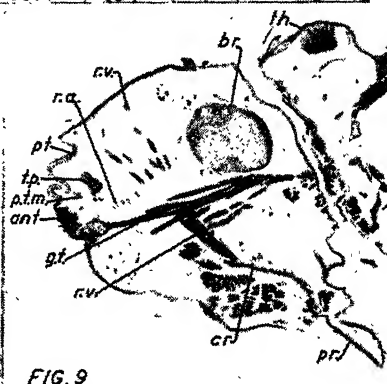
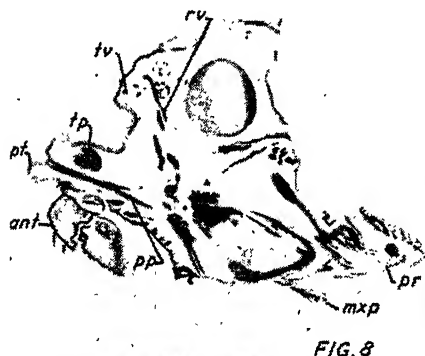
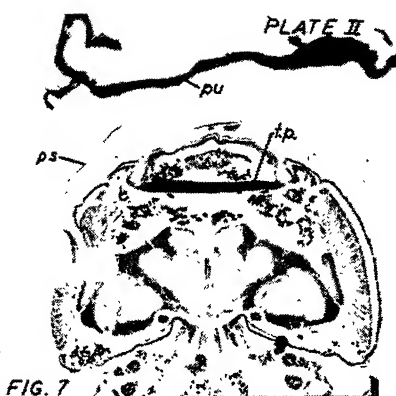
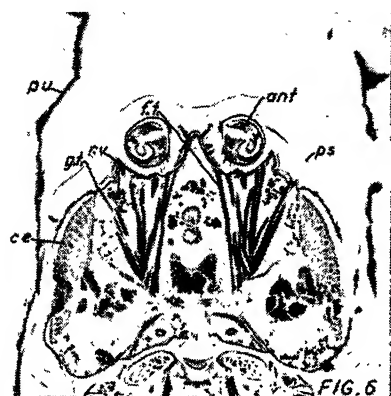
*Lunular muscle* (figs. 2 and 3, *l.m.*).—Jobling (1933) described this muscle in *Glossina* under the name "retractors of the fronto-clypeus," and it seems to be quite similar in *Glossina*, *Calliphora*, and *Drosophila* in that it is an unpaired, long, thin muscle arising from the dorsal rim of the occipital foramen. It passes between the supra- and sub-oesophageal ganglia and is attached to the lunule of the fronto-clypeus dorsad of the antennal bases close to the caudal edge of the ptilinal or frontal suture. It retracts the fronto-clypeus and the ptilinum after emergence. It first appears in 30-hour pupae (fig. 2, *l.m.*) and persists after emergence beyond 10-day old imagines without any apparent deterioration. Its function in the imagines after emergence is not known.

*Oculo-antennal muscles* (fig. 9, *r.a.*).—These are the "retractors of the antennae" of Jobling (*l.c.*) who states that this pair of muscles arises from the lateral margins of the vertex and passes through the scape, the first antennal segment, and becomes inserted on a short process of the dorsal part of the caudal region of the pedicle, the second antennal segment. In *D. melanogaster* this pair of muscles appears to be inserted on the ocular sclerites at the dorsocephalic margin of the compound eyes instead of on the vertex as in *Calliphora* and to be consistent in terminology should be termed the *oculo-antennal muscles*.

This pair of muscles assists in deflating the head during emergence by approximating the vertex and fronto-clypeus; subsequently, it functions only as the antennal retractors. They first appear in 54-hour pupae and persist until they are almost completely dissipated in 72-hour imagines.

*Fronto-pharyngeal muscles* (fig. 9, *r.v.*).—This pair of muscles is the "retractors of the vertex" of Laing (*l.c.*) and arises from the caudal surface of the cornua (fig. 9, *c.r.*) of the basipharynx and is inserted partly on the ocular sclerites and partly on the lateral margins of the vertex caudad of the *oculo-antennal muscles*. These muscles appear to pull in the vertex during the deflation of the head. To be consistent in terminology, these muscles should be termed the *fronto-pharyngeal muscles*, the terminology which was used by Mercier and Villeneuve. These muscles appear to be just forming in 54-hour pupae and are being absorbed rapidly in 12-hour imagines.

*Tentorio-pharyngeal muscles* (fig. 2, *t.ph.*).—There is also an additional pair of muscles attached cephalad of the cornua of the basipharynx



#### EXPLANATION OF PLATE II

FIG. 6. Microphotograph of dorso-ventral section of head of 102-hour pupa. FIG. 7. Microphotograph of dorso-ventral section of head of 102-hour pupa. FIG. 8. Microphotograph of sagittal section of head of adult one-half hour after emergence. FIG. 9. Microphotograph of sagittal section of head of adult, one-half hour after emergence. FIG. 10. Microphotograph of cross-section of head of adult, one-half hour after emergence. FIG. 11. Microphotograph of dorso-ventral section of head of adult, two hours after emergence.



("fulcrum" of Laing and other authors) and are attached caudad of the tendons of the tentorium along with the ptilino-tentorial muscles. Since the basipharynx of the proboscis is movable, it seems that this set of "tentorio-pharyngeal muscles" is also necessary to aid the ptilino-pharyngeal muscles to retract the ptilinum during and after emergence of the imagines, and they are subsequently retained as retractors of the proboscis. This set of muscles is first seen in 30-hour pupae and persists at least through the 10-day old imagines and shows no evidence of being absorbed..

#### THE USE OF THE PTILINUM IN EFFECTING EMERGENCE OF THE IMAGINES FROM THE PUPARIA

The emergence of the imagines of *D. melanogaster* occurs much the same way as that described by Laing (*l.c.*) for *Calliphora*. Emergence occurs after a pupal period averaging 102 hours when reared at 21.5° C. and 69 percent relative humidity. The puparium is ruptured along two fissures—a longitudinal and a circular one (fig. 1, *l.f.* and *c.f.*). The longitudinal fissure extends around the cephalic end and along the sides, external to but in the same line as, the main tracheal trunk of the larva, until it meets the circular fissure which runs around only the laterodorsal portion of the cephalic margin of the fourth visible segment above the longitudinal fissure. The ruptured dorso-cephalic lid hinges back when forced open and never breaks off as in *Calliphora*. This rupturing is effected by the alternate inflation and retraction of the ptilinum, the resulting pulsation usually continuing regularly for from one-half to five minutes after emergence. The inflation is brought about by pressure of the haemolymph being forced into the head by contraction of the abdominal and thoracic regions. The whole head capsule including the proboscis becomes very much distended. The head is distended principally along the longitudinal axis, but then apparently by contraction of the geno-tentorial muscles and probably aided by the transverse-ptilinal muscle it becomes narrower laterad, especially after the edges of the longitudinal fissure have separated. The withdrawal of haemolymph from the head is probably effected by the relaxation of the abdominal and thoracic muscles and by contraction of the ptilinal and associated head musculature, and the ptilinum is invaginated by the contraction of the ptilinal and associated musculature as described earlier. The continued periodic inflation and distension of the ptilinal region and the head capsule probably facilitates the passage of the thorax and abdomen through the constricted opening of the puparium since the puparium does not rupture at its largest diameter.

The observed time of rhythmic pulsations averaged three seconds in the inflated and one second in the deflated condition. The imagines usually took an average of one to three minutes to effect emergence under observation; however, the pulsations begin as early as 12 hours before rupturing of the puparium and last up to 10 minutes after emergence is completely effected. The setae and bristles on the body appear to prevent the imago from slipping back into the puparium during contraction and relaxation of the abdomen.

SUBSEQUENT CHANGES IN THE PTILINUM AND  
ASSOCIATED MUSCULATURE

The cuticula of the ptilinum in newly emerged flies is very similar in structure to that of the neighboring integument as was previously mentioned. In flies over 24 hours old, the cuticula of the vertex is fully hardened and pigmented and consists of an ectal, yellow, refractive layer, pilose externally, which is not stained with Heidenhain's haematoxylin and which contains pigment. There is also a thinner, less refractive, ental layer which stains readily and which represents the living hypodermal cell layer. However, the cuticula of the invaginated ptilinum is now becoming quite different. The ptilinal cuticula of the imago is two times as thick as the cuticula of the remainder of the head capsule until after the eighth day, at which time it becomes somewhat thinner. At this time it is composed only of an ectal layer which is less refractive, is but slightly stainable, and has no pigment. By the end of the tenth day in the imago the ptilinal integument is reduced to two-thirds the thickness of the integument of the head capsule. The infolded and invaginated ptilinal integument now consists of a thin layer which bears the spinules. The reduction in the thickness of the ptilinal integument is not so marked as in *Calliphora*. In Laing's work on *Calliphora* it is reduced to one fifth of the original thickness at emergence whereas in *D. melanogaster* it is reduced to one third of the original thickness at emergence.

At the end of 24 hours after emergence, all the muscles connected directly to the ptilinum have been completely absorbed. At the end of 96 hours all the muscles which are associated with retraction of the ptilinum have been completely absorbed with the exception of two sets. These are the lunular muscle (fig. 2, *l.m.*) and the tentorio-pharyngeal muscles (fig. 2, *t.ph.*). The lunular muscle has not degenerated and its subsequent function has not been determined since it serves as a retractor of the fronto-clypeus during emergence and since after emergence the fronto-clypeus remains fixed in relation to the remainder of the head capsule. The tentorio-pharyngeal muscles persist as retractors of the proboscis. Laing states that the retractors of the antennae (*oculo-antennal muscles*), (fig. 9, *r.a.*) persist in *Calliphora* after the second day but are non-functional. In *D. melanogaster*, however, the *oculo-antennal muscles* have completely disintegrated after 72 hours. The air sacs of the head become enlarged and distended after 24 hours, and as the muscles are lost, the space is filled with distended air-sacs limiting the space available for haemolymph.

Laing (*l.c.*) suggested that in *Calliphora* the degeneration of the ptilinal musculature was probably associated with the disuse of the muscles concerned and that the distension of the cephalic air sacs, resulting in cutting off much of the haemolymph supply, probably is significant in their degeneration. The author disagrees with Laing and suggests that since this degeneration takes place so rapidly in most instances in *D. melanogaster* that primarily degeneration is effected immediately upon cessation of the ptilinal pulsations by a release of histolytic enzymes from the nuclei of the muscles concerned. It would seem that this is true because if these enzymes were contained in the body fluid, all of the muscles, including the persisting proboscal musculature, would degenerate. There is no evidence in the imagines of

*D. melanogaster* that phagocytosis effects histolysis as in the pupal stage. This agrees with Laing's work since although phagocytes are present, they are not found in close relation to degenerating muscle-fibers.

#### DISCUSSION

Laing (*l.c.*) presents a thorough, comparative discussion of the origin and development of the ptilinum in the Diptera; therefore, the author will not rediscuss this work here.

The author agrees with Laing in that the ptilino-pharyngeal muscle has no function other than aiding in retracting the ptilinum since all traces of it disappears before 12 hours after adult emergence in *D. melanogaster*. It appears that Mercier and Villeneuve (*l.c.*) were in error in supposing that this muscle was retained as the pharyngeal dilator in the ptilinal-bearing Diptera after emergence is effected. However, the ptilino-pharyngeal muscle offers an interesting study in evolutionary changes in function. In the Nematocera (Culicidae, Knab, *l.c.*) this muscle acts as a pharyngeal dilator during emergence since by contraction of this muscle air is sucked into the alimentary canal and serves to distend the body and makes the body firmer. In the Aschiza (*Eristalis*, Becher, 1882) this muscle has little or no function since air in the alimentary canal is not used to aid in effecting emergence and since there is no ptilinum. In the Schizophora and in both the Acalyptratae and Calyptratae (*Drosophila* and *Calliphora*, respectively), a ptilinum is present, and in these instances this muscle acts only as a retractor of the ptilinum. So we can easily see that this muscle functions in three different ways in three groups of Diptera, acting in *D. melanogaster* as an aid only in the emergence of the imagines. All of the muscles mentioned in this work seem to be present almost solely for the purpose of effecting emergence of the imagines, with the exception of the lunular and the tentorio-pharyngeal muscles, since all of these muscles degenerate so rapidly.

#### SUMMARY

1. An account is given of the morphology, development, and changes of the ptilinum prior to, during, and following emergence of the pomace fly, *Drosophila melanogaster* Meigen.

2. The ptilinum develops from the integument of the cephalic portion of the frontal sac of the head region. Differentiation from the adjacent vertex, fronto-clypeus, and genae begins first as a local thickening of the epidermis. At the end of six hours after pupation at 21.5° C. and 69 percent relative humidity, this epidermal thickening grows inwardly, and as its surface area increases, its walls become gradually thinner. Rudiments of the ptilino-pharyngeal muscle are visible immediately after eversion of the head (in 30-hour pupae) at which time many of the other muscles appear. All ten sets of muscles discussed have appeared in 78-hour pupae.

3. In the freshly emerged fly the ptilinum is continuous with the integument of the vertex, fronto-clypeus, and genae. Two unpaired and one pair of retractor muscles are inserted on the ptilinum; seven other muscles apparently are used in connection with the pulsation of the head during emergence.

4. By rhythmic expansion and contraction of the ptilinum,

the puparium and pupal sheath are ruptured, and emergence of the fly is effected. After final retraction of the ptilinum into the head capsule, no more use is apparently made of the organ.

5. In 10-day old adults the ptilinal integument is reduced to a layer of spinules. Before 48 hours have elapsed after emergence, practically all of the ptilinal and associated accessory muscles have disappeared. Their dissipation does not appear to be due to phagocytic activity. The author suggests that such rapid dissipation may possibly be due to the release of histolytic enzymes from the nuclei of the muscles concerned.

6. The evolution of functions of the ptilino-pharyngeal muscle is traced through the order Diptera. From the evidence brought forward it is suggested that the Nematocera, Aschiza, and Schizophora represent three independent lines of genetic development.

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# A REVISION OF THE AMERICAN SPECIES OF DICERATOSMIA

(Hymenoptera, Megachilidae)

CHARLES D. MICHENER

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The genus *Diceratosmia* is closely related to the large and well known genus *Osmia*. It has been separated, however, by recent authors (Sandhouse, 1939; Michener, 1941, 1944) largely on the basis of the longitudinal carina along the inner ventral angle of each posterior coxa. There are also certain other generic characters, as detailed by Michener (1941).

## Genus *Diceratosmia* Robertson

*Diceratosmia* Robertson, 1903, Trans. Amer. Ent. Soc., 29: 166.

Type: *Osmia quadridentata* Cresson, = *Osmia conjuncta* Cresson (original designation).

## KEY TO THE AMERICAN SPECIES OF DICERATOSMIA

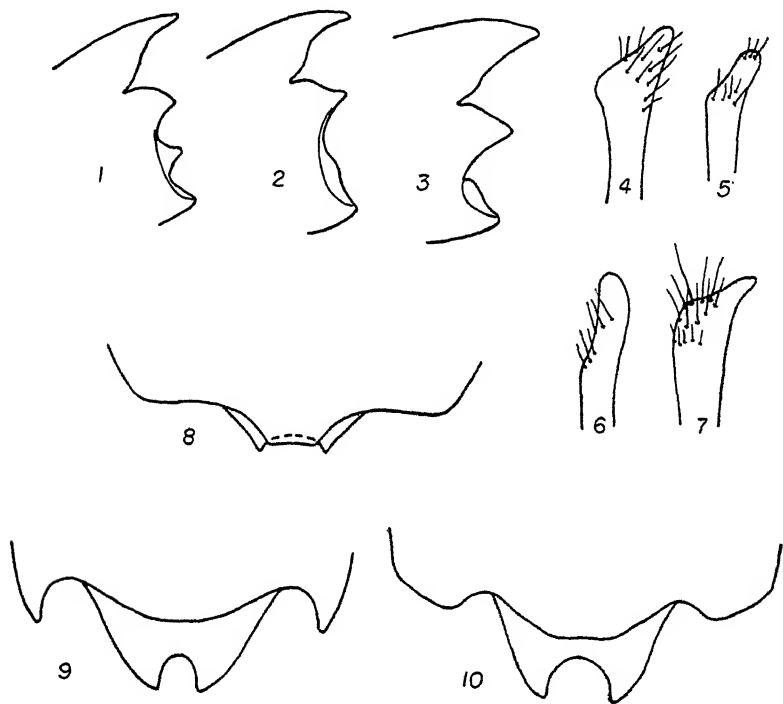
1. Body black; pubescence long, red or reddish; mandibles of female quadridentate (Mexico to Costa Rica)..... **azteca**  
Body blue; pubescence short, whitish; mandibles of female tridentate, sometimes with weak convexity between second and third teeth (United States and Northern Mexico).....2
2. Males.....3  
Females.....5
3. Seventh abdominal tergum produced at each side to a large acute tooth similar in shape to the teeth of the eighth tergum.....4  
Seventh abdominal tergum at each side with an obtusely rounded projection, much shorter and broader than teeth of eighth tergum..... **subfasciata**
4. First flagellar segment at least as long as second; antennae and tegulae black, **conjuncta**  
First flagellar segment shorter than second; antennae and tegulae partly brown..... **botitena**
5. Distance between first and second mandibular teeth less than that between second and third..... **conjuncta**  
Distance between first and second mandibular teeth subequal to that between second and third..... **subfasciata**

## *Diceratosmia azteca* (Cresson)

*Female*.—Length .85 to 12.5 mm. Black with long reddish pubescence; head and thorax rather finely and closely punctate, propodeal enclosure dull and roughened; clypeus with median truncation, the margin of which is rather broadly impunctate; truncation shorter than distance from its end to lateral angle of clypeus, and projecting somewhat anteriorly so that angles demarking truncation are more conspicuous when viewed from above than from in front; distance between posterior ocelli far less than distance from one of them to posterior margin of vertex or to eye margin; mandible quadridentate (fig. 1), carinae of outer face expanded basally to form large smooth flat area obliquely placed on mandible; genal areas wider than eye seen

from side; dorsum of second abdominal tergum with punctures as coarse as thorax, but other terga much more finely punctate, the punctures rather close except middorsally on third and fourth terga; all terga with erect pubescence which is more abundant along posterior margins.

*Male*.—Length 8 to 10 mm. Similar to female; clypeal margin approximately as in *D. conjuncta*; mandibles bidentate, with smooth flat area on outer surfaces less extensive than in female; antennae



FIGS. 1 to 3. Apices of mandibles of females: 1, *D. azteca*; 2, *D. conjuncta*; 3, *D. subfasciata*. FIGS 4 to 7. Apices of male gonocoxites (inner margin to right): 4, *D. subfasciata subfasciata*; 5, *D. bolitena*; 6, *D. conjuncta*; 7, *D. azteca costaricensis*. FIGS. 8 to 10. Posterior margins of seventh and eighth abdominal terga of male: 8, *D. azteca azteca*; 9, *D. conjuncta*; 10, *D. subfasciata subfasciata*.

reaching well behind tegulae, first flagellar segment conspicuously shorter than second; third abdominal sternum large, broadly rounded, sometimes feebly emarginate medially; fourth broadly emarginate with very long fringe; fifth with margin broadly rounded except for feeble median concavity; seventh tergum with broadly obtuse lateral angles and narrow median (sometimes feebly emarginate) produced truncation (fig. 8); eighth tergum bidentate; coxopodite of genitalia rather broad subapically, abruptly narrowed to inward directed process (fig. 7).

**Diceratosmia azteca azteca (Cresson)**

*Osmia azteca* Cresson, 1878, Trans. Amer. Ent. Soc., 7: 105.

*Diceratosmia azteca*, Sandhouse, 1939, Mem. Ent. Soc. Washington, 1: 139.

*Osmia erythrotricha* Cockerell, 1912, Ann. Mag. Nat. Hist., (8)9 561; Cockerell, 1949, Proc. U. S. Nat. Mus. 98: 450.

Usually larger than the following form; genal area of female little more finely punctate than mesepisterna; emargination between teeth of eighth tergum of male semicircular.

The type of *azteca*, in the Academy of Natural Sciences of Philadelphia, is from an unknown locality in Mexico. Specimens have been studied from near Mexico City, Mexico, September 1, 1897 (O. W. Barret). The type of *erythrotricha* was merely labeled "Guatemala." It has not been available for study but the name seems almost certainly synonymous with *azteca*. An additional specimen from Río Pensativa, Guatemala, is recorded by Cockerell.

**Diceratosmia azteca costaricensis (Friese)**

*Osmia costaricensis* Friese, 1925, Stettiner Ent. Zeitung, 86(2): 37.

Usually smaller; genal areas of female distinctly more finely punctate than mesepisterna; emargination between teeth of eighth tergum of male broad and shallow.

Specimens have been studied from San Jose, Costa Rica, 1898 and 1923.

**Diceratosmia conjuncta (Cresson)**

*Osmia conjuncta* Cresson, 1864, Proc. Ent. Soc. Philadelphia, 3: 31; Robertson, 1897, Trans. Acad. Sci. St. Louis, 7: 347; Friese, 1911, Das Tierreich, Lf. 28, p. 150; Cresson, 1916, Amer. Ent. Soc., Mem. 1, p. 116; Viereck, 1916, Connecticut Geol. Nat. Hist. Surv. Bull., 22: 750; Sandhouse, 1925, Canad. Ent., 57: 36, 64; Leonard, 1926, Cornell Univ. Agr. Expt. Sta., Mem. 101: 1030; Robertson, 1928, Flowers and Insects, p. 8; Graenicher, 1935, Ann. Ent. Soc. Amer., 28: 305; Rau, 1937, Ann. Ent. Soc. Amer., 30: 330; Brimley, 1938, Insects North Carolina, p. 458.

*Diceratosmia conjuncta*, Sandhouse, 1939, Mem. Ent. Soc. Washington 1: 139.

*Osmia 4-dentata* Cresson, 1878, Trans. Amer. Ent. Soc., 7: 107.

*Osmia quadridentata* Dalla Torre, 1896, Cat. Hymen., vol. 10, p. 392; Cresson, 1916, Mem. Amer. Ent. Soc. 1: 120.

*Diceratosmia quadridentata* Robertson, 1903, Trans. Amer. Ent. Soc., 29: 171.

*Osmia cressonii* Dalla Torre, 1896, Cat. Hymen., vol. 10, p. 392.

*Female*.—Length 8 to 9 mm. Dull blue with whitish pubescence; head and thorax rather finely and closely punctate except for mesoscutellum which is conspicuously more coarsely punctate than rest of thorax; propodeal enclosure dull and roughened, especially above. Clypeus with median often somewhat emarginate truncation, its margin black and narrowly impunctate; truncation shorter than distance from its end to lateral angle of clypeus; distance between posterior ocelli slightly less than distance from one of them to eye margin or to posterior margin of vertex; mandible tridentate with slight convexity between second and third teeth (fig. 2); distance between first and second teeth conspicuously less than that between second and third; mandible without flat shining area on outer surface; genal areas about as wide as eyes, seen from side; abdomen more finely punctured basally than most parts of thorax, but fifth and sixth terga about as coarsely punctured as mesoscutum.

*Male*.—Length 7.5 mm. to 8.5 mm. Similar to female; clypeal margin with short, slightly concave median section demarked by weak angles; mandibles bidentate; antennae brownish black, reaching somewhat behind tegulae; first flagellar segment at least as long as second, flagellar segments except the last less than twice as long as broad; distance between posterior ocelli equal to distance from one of them to eye margin or posterior margin of vertex; third abdominal sternum large and broadly rounded posteriorly, sometimes with feeble median emargination; fourth broadly emarginate with long fringe arising from emargination; fifth broadly rounded; seventh tergum with strongly produced lateral angles (fig. 9); eighth bilobed; coxopodite of male genitalia slender apically (fig. 6).

*Distribution*.—Connecticut, Ontario, and Wisconsin south to North Carolina and Missouri. ONTARIO: Toronto. NEW YORK: Ithaca. WISCONSIN: Milwaukee. ILLINOIS: Augerville, Carlinville. MISSOURI: St. Louis. MARYLAND: Cabin John, Plummers Island. VIRGINIA: Edsall, Great Falls, Chevy Chase, Falls Church.

Specimens have been collected as early as March 24 (St. Louis) but most collection records are in May. The latest is June 1 (Maryland).

This bee visits a wide variety of flowers, as shown by the following list: *Taraxacum dens-leonis*, *Viola rafinesquii*, *Rubus procumbens*, *Dentaria laciniata*, *Lupinus perennis*.

The types of both *conjuncta* and 4-*dentata* (= *cressonii*) are in the Academy of Natural Sciences of Philadelphia.

### *Diceratosmia botitena* Cockerell

*Osmia botitena* Cockerell, 1909, Ann. Mag. Nat. Hist., (8)4: 30; Michener, 1936, Bull. Southern California Acad. Sci., 35: 85.

*Osmia conjuncta marilaunidii* Cockerell, 1914, Ann. Mag. Nat. Hist., (8)14: 363.

Although the above names were placed in synonymy with *D. subfasciata* by Sandhouse (1939), there is little doubt that either a distinct species or a very distinctive Texan subspecies of *D. conjuncta* exists. Certainly the form described as *marilaunidii* is not closely related to *subfasciata*. Unfortunately, the type (a female) of *botitena* cannot now be found (it is not in the United States National Museum nor in the Timberlake collection), and no other females of this form are available. However, this type was before me, in the Cockerell collection, when I wrote (Michener, 1936), "Top of head and thorax green, the punctures smaller (than in *subfasciata*) and about as close as they can be except in center of scutum." From this information, plus certain details from the original description, it is evident that *botitena* is much like *conjuncta*, although the latter is consistently blue. It is not known whether the arrangement of the mandibular teeth is as in *conjuncta*.

The male of *botitena* is thought to be *marilaunidii* although admittedly, in the absence of more information about the female (*botitena*), this is subject to some doubt.

*Male*.—Length 7 mm. Green or brassy green, bluer laterally. Punctuation fully as fine as in *conjuncta*; clypeal margin with small but distinct median emargination marked by small but subacute angles; mandibles bidentate; antennae reaching well behind tegular, flagellum brown, dark above; first flagellar segment distinctly shorter than second,



third to tenth flagellar segments twice as long as broad; distance between posterior ocelli equal to distance from one of them to eye margin or to posterior margin of vertex; third abdominal sternum large and broadly rounded posteriorly, fourth emarginate with long fringe arising from emargination, fifth rounded but more produced posteriorly in the middle than in either *conjuncta* or *subfasciata*; seventh abdominal tergum with strongly produced lateral angles and eighth bilobed; coxopodite of male genitalia slightly broadened subapically.

*Distribution*.—Texas. This appears to be a rare species. The holotype of *botitena* was from Lee County. The holotype of *marilaunidii* was from Devil's River. Another male specimen is from Kerrville, Texas, on *Nothoscordum*, March 27, 1906 (F. C. Pratt).

### *Diceratosmia subfasciata* (Cresson)

*Female*.—Length 7.5 to 9 mm. Dull blue or purplish with whitish pubescence; head and thorax rather coarsely punctate with more conspicuous shining interspaces between punctures in many areas, especially the mesoscutum, than in *conjuncta*; mesoscutellum usually scarcely more coarsely punctate than posterior portion of mesoscutum; propodeal enclosure dull and roughened above but shining below. Clypeus with median, often somewhat emarginate, truncation, its margin black and narrowly impunctate; truncation shorter than distance from its end to lateral angle of clypeus; distance between posterior ocelli equal to distance from one of them to eye margin, equal to or slightly less than distance from one of them to posterior margin of vertex; mandible tridentate with very feeble convexity between second and third teeth (fig. 3); distance between first and second teeth slightly greater than distance between second and third; mandible without flat shining area on outer surface; genal areas about as wide as or slightly wider than eyes, seen from side; basal abdominal terga with punctures about as coarse as or finer than those of mesepisterna, punctures coarser apically, coarsest on penultimate tergum.

*Male*.—Length 6 mm. to nearly 9 mm. Similar to female; clypeal margin with short, slightly concave median section demarked by weak angles; mandibles bidentate; antennae reaching somewhat behind tegulae, first flagellar segment shorter than second, flagellar segments except apical one less than twice as long as broad; distance between posterior ocelli equal to distance from one of them to posterior margin of vertex; third abdominal sternum large and broadly rounded posteriorly, fourth broadly emarginate with long fringe arising from emargination; fifth broadly rounded; seventh abdominal tergum with posterior lateral lobes broad and rounded (fig. 10), eighth bidentate; coxopodite of male genitalia broadened subapically, the apical margin oblique (fig. 4).

### *Diceratosmia subfasciata subfasciata* (Cresson)

*Osmia subfasciata* Cresson, 1872, Trans. Amer. Ent. Soc., 4: 261; Birkman, 1899, Ent. News, 10: 245; Cockerell, 1907, Univ. Colorado Studies, 5: 37; Cockerell, 1911, Proc. U. S. Natl. Mus., 40: 255; Friese, 1911, Das Tierreich, Lf. 28, p. 158; Cockerell, 1914, Canad. Ent., 46: 411; Cresson, 1916, Mem. Amer. Ent. Soc., 1: 131; Michener, 1936, Bull. Southern California Acad. Sci., 35: 85.  
*Diceratosmia subfasciata*, Sandhouse, 1939, Mem. Ent. Soc. Washington 1: 140; Michener, 1947, Amer. Midland Nat., 38: 450.

This is a small subspecies (females usually about 7.5 mm. long, sometimes 8.5; males usually about 6.5 mm.). The punctation is coarse, that of the posterior part of the mesoscutum being as coarse as that of the mesoscutellum. The color is blue. The lateral lobes of the seventh tergum of the male are more evenly rounded than in the subspecies *conjunctoides*, and the lobes of the eighth tergum are narrowly rounded at their apices.

*Distribution*.—Northeastern Mexico and Texas to eastern Kansas, eastward to Mississippi and Tennessee; a doubtful record from New Jersey. TAMAULIPAS: Matamoros. TEXAS: Brownsville, Cotulla, Cresson, Dallas, Devil's River, Edna, Falfurrias, Fedor, Gainesville, Harlingen, Kerrville, Ladonia, Llano, Mineral, Neuseest, Paris, Plano, San Antonio, Victoria, Waco, Weatherford, Willis. OKLAHOMA: Hugo, Ardmore. KANSAS: Baldwin. TENNESSEE: Nashville. LOUISIANA: Opelousas. MISSISSIPPI: Hattiesburg. NEW JERSEY: Camden County?

Specimens have been collected as early as March 7 at Brownsville, Texas, but the majority of records are in May, with a few in June, the latest being June 26 at Dallas, Texas.

This bee visits a wide variety of flowers as shown by the following flower records: *Prunus*, *Rubus*, *Cercis canadensis*, *Achillea*, *Gaillardia pulchella*, *Marilaunidium organifolium*, *Coreopsis cardaminefolia*, *Helianthus*, *Monarda citriodora*.

The type, from Texas, is in the Academy of Natural Sciences of Philadelphia.

#### *Diceratosmia subfasciata punctata* (Michener)

*Osmia punctata* Michener, 1936, Bull. Southern California Acad. Sci., 35: 85.

*Diceratosmia subfasciata punctata*, Linsley and MacSwain, 1947, Jour. Econ. Ent., 40: 354.

This subspecies is very similar to typical *subfasciata* but is usually larger (females nearly 9 mm. long) and a little more coarsely punctate and the head in particular is larger, and longer posteriorly, so that unlike most females of typical *subfasciata*, the distance from a posterior ocellus to the posterior edge of the vertex is distinctly greater than the distance between the posterior ocelli.

*Distribution*.—The desert regions of Southern California and Arizona. CALIFORNIA: Death Valley, Imperial County, Blythe, Coachella, Oasis. ARIZONA: Yuma.

Specimens have been collected from March to June.

This bee has been collected on flowers of *Heliotropium* and *Prosopis glandulosa*.

The type is at present on deposit in the California Academy of Sciences, San Francisco.

Specimens collected by the author at Edna and 15 miles north of Harlingen, Texas, April 2 and 4, 1946, resemble *punctata* and differ from most Texas specimens of this species in their large size. Moreover, a male collected at Oasis, California, by Doctor E. G. Linsley is as small as Texas males, although another male collected at the same time is 7 mm. long.

**Diceratosmia subfasciata conjunctoides** (Robertson)

*Osmia conjunctoides* Robertson, 1893, Trans. Amer. Ent. Soc., 20: 276; Friese, 1911, Das Tierreich, Lf. 28, p. 151.

*Osmia subfasciata* Graenicher, 1930, Ann. Ent. Soc. Amer., 23: 163.

Specimens from southern Florida are so different from typical *subfasciata* that they were at first thought to represent a distinct species. However, through the courtesy of Doctor H. H. Ross, a paratype of *Osmia conjunctoides* Robertson has been available for study. This form was described from Citrus County, in the northern part of peninsular Florida. It is clearly an intergrade between typical *subfasciata* and the form of southern Florida. It has the coloration of the latter form, while the size and the shape of the seventh and eighth abdominal terga of the male are intermediate. It is unfortunate that the type locality of *conjunctoides* is not in southern Florida, where the special characteristics of the Florida population are accentuated. However, the name *conjunctoides* does seem applicable to the population of the whole of peninsular Florida. The following description is based upon material from southern Florida:

This subspecies differs from typical *subfasciata* in its larger size (length of both sexes 8.5 to 9 mm.), darker blue or purplish coloration, and finer and denser punctation. The punctures of the mesoscutum are considerably finer, even posteriorly, than those of the mesoscutellum. Thus the punctation is similar to that of *conjuncta*. The lateral lobes of the seventh tergum of the male are slightly angulate laterally, unlike *subfasciata*, and the lobes of the eighth tergum are longer and more angulate at the apices than in *subfasciata*.

*Distribution*.—Peninsular Florida (northern specimens seem to intergrade with *subfasciata*). FLORIDA: Citrus County, Charlotte Harbor, Miami, Biscayne Key.

One Miami specimen is labeled January. Graenicher records dates of capture from February 8 to March 17.

The type, from Citrus County, Florida, is in the collection of the Illinois Natural History Survey, Urbana, Illinois.

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# A POPULATION STUDY OF THE ANT *APHAENOGASTER* *FULVA* SSP. *AQUIA* BUCKLEY

(Hymenoptera, Formicidae)

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This is one of a series of ant population studies and it correlates with a previous paper on populations of two species of *Leptothorax* (Headley, 1943), in which other ant population works were cited, and with a more recent study of *Myrmica schencki* ssp. *emeryana* Forel (Talbot, 1945). The paper deals with *Aphaenogaster fulva* ssp. *aquia* Buckley, a myrmicine ant which is rather widely distributed in the northeastern United States.

For a population study of an ant it is desirable to find numerous colonies living together in one habitat, where it is supposed that conditions of soil, plant cover, temperature, light, humidity and food all blend to make the area a good one for that species. Furthermore, colonies need to be studied throughout the summer to trace the maturing of brood. If all the colonies come from one habitat, other variables, beside the desirable one of time, are held at a minimum. Such an *Aphaenogaster fulva aquia* community was found in Seneca County of north central Ohio.

*Description of habitat.*—The *Aphaenogaster* plot was a grove of young locust trees one tenth of an acre in size. Under the canopy of trees was a luxuriant, head-high growth of weedy plants: giant ragweed, tall blue lettuce, elderberry, blackberry, burdock, goldenrod and fleabane. Smaller groundcover plants were scarce except at the edges of the grove.

The floor of the locust woods was characteristic, for here there was no heavy matting of leaves such as occur in a beech-maple or an oak forest, but rather an accumulation of leaves and stems. The small locust leaflets dried out readily and curled into crisp brown fragments. They became tangled with the dead locust twigs, elderberry and blackberry branches and stems of nettle, tall blue lettuce and ragweed, making a loose trashy layer upon the soil. The ground itself was a very loose black loam for 3 to 4 inches, solid brown soil for another 10 to 12 inches and below that hard yellow clay. There were no stones or rocks, but roots interlaced in all directions.

All of these conditions taken together seemed to make a good habitat for *Aphaenogaster fulva aquia* because colonies were found in abundance. The soil held moisture well and the dense covering of tall weeds affected the humidity of the ground as well as its surface which remained moist except in extremely dry weather. But it was the litter on the surface of the ground that seemed especially favorable for *Aphaenogaster*. The ants used the leaves, twigs and hollow stems in various ways for nest cover and above-ground chambers for speeding the development of young ants.

The locust woods was not only a favorable location for *Aphaenogaster fulva aquia* but it also harbored a number of other ant species. *Stenamma brevicorne* Mayr was abundant just under the surface of the soil and *Brachymyrmex heeri depilis* Emery was occasionally encountered. *Ponera coarctata pennsylvanica* Buckley, a subterranean ant, was common, and *Stigmatomma pallipes* Haldeman was found in the upper two inches of soil. *Prenolepis imparis* Say nests were frequently cut into while digging for *Aphaenogaster*, and other ants, such as *Tapi-noma sessile* Say, *Myrmica schencki emeryana* Forel, *Leptothorax curvispinosus* Mayr, *Solenopsis molesta* Say and *Lasius niger alienus americanus* Emery, patrolled the surface. The woods was also invaded by ants which nested near its rim. These were *Aphaenogaster tennesseensis* Mayr, *Camponotus caryae* Fitch, *Camponotus herculeanus pennsylvanicus* De Geer, *Formica fusca subsericea* Say and *Formica pallidefulva schaufussi incerta* Emery. Thus there was in the woods a cosmopolitan mixture of sixteen kinds of ants, each colony a community in itself, yet living together in a restricted habitat with seemingly ample food and nesting space.

*Nest structure.*—In other localities *Aphaenogaster fulva aquia* nests are often under stones, in much-decayed logs, under layers of leaves, or more seldom in open ground. But at the locust grove they were almost always covered with a trashy litter. Twigs, small bits of plant stems and curled up locust leaves covered the nests. Ants were traced home by giving them bits of cake crumbs, and usually they simply disappeared among the leaves. Then the covering had to be picked away and a hunt made for the nest entrance in the soil. Picking away the litter had to be done carefully for often there were larvae and pupae piled among the leaves, thus making them serve as above-ground brood chambers. Entrances were sometimes hard to find, for the ants occasionally had passageways under the leaves for several inches. Usually the soil about the entrance was loose and it might be raised a little from the surrounding surface. In this loose soil entrances were sometimes nicely rounded and definite holes one-eighth to one-fourth inch in diameter, sometimes natural-looking cracks. Most nests had more than one entrance; the average was 2.3 and the extreme found was 8. Usually the multiple entrances were within three or four inches of each other, but they were sometimes as much as eight inches apart.

After entrances were located, they were filled with white ink which ran down and so marked the galleries. Then a half-moon shaped hole was dug to the side of the nest area so that the nest could be uncovered layer by layer. Usually the ground was black, loose, and crumbly and mixed with debris for the first few inches. This made near-the-surface chambers hard to determine because digging tended to cave them in. When multiple openings occurred, there were one or two horizontal galleries connecting them and from one to seven chambers within the first two inches of soil (Figures 1 and 2). Below two or three inches, galleries tended to converge and extended vertically down into the more solid soil. Usually there was only one such gallery but cases of two, three or even four were found. Along the gallery, chambers extended out and housed workers, pupae, larvae and eggs. The nests

dug averaged 6.5 chambers with extremes ranging from 2 to 17. Chambers had rounded ceilings and flat floors and were rather uniformly one-half inch high. They were three-fourths to two inches long and about one-half inch wide. Nests varied greatly as to depth from no depth at all, in colonies which were living entirely above ground, to 34 inches, with a mean depth of 9.03 inches. Depths were recorded for separate months to see if seasonal variation could be detected.

Month	Number of Nests	Mean Depth	Range
June.....	14	5.18	0-20
July.....	11	5.83	0-20
August.....	15	14.93	8-34

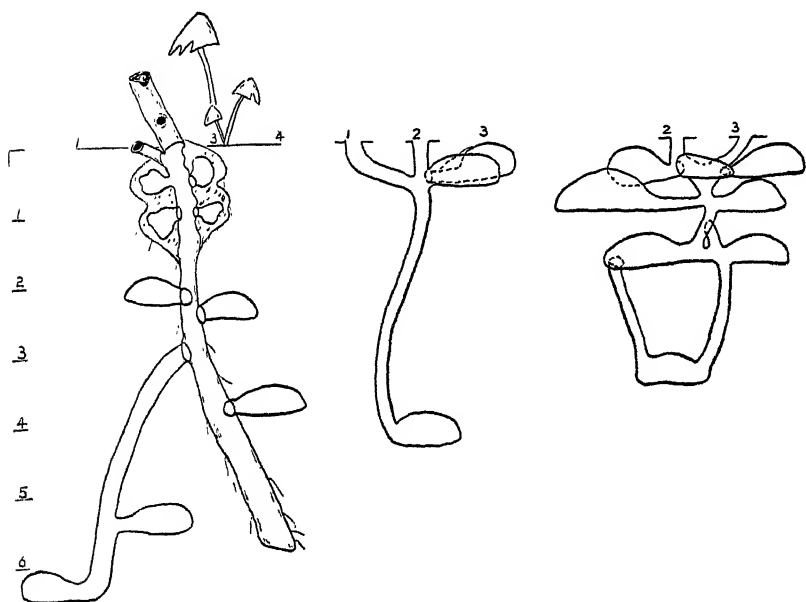


FIG. 1. Three types of small nests of the ant *Aphaenogaster fulva aquia*. A. Nest using small bit of stem and root of plant; dug July 20, 1946. B. Small simple nest; dug June 12, 1946. C. Typical shallow nest with chambers near surface; dug June 11, 1946.

The greater depth of nests in August may have been due to drier conditions, for it has been noticed that *Aphaenogaster* tend to bring their brood to the surface during wet weather and to go deeper during dry. No correlation between size of nest and size of colony could be detected.

*Variation in nests.*—*Aphaenogaster fulva aquia* showed versatility in using a variety of materials to supplement or even replace the nests excavated in the soil. Some examples follow. Two colonies were nesting in the trunks of dead, standing locust trees. There was no connection of the nest with the soil, entrances were a little above the

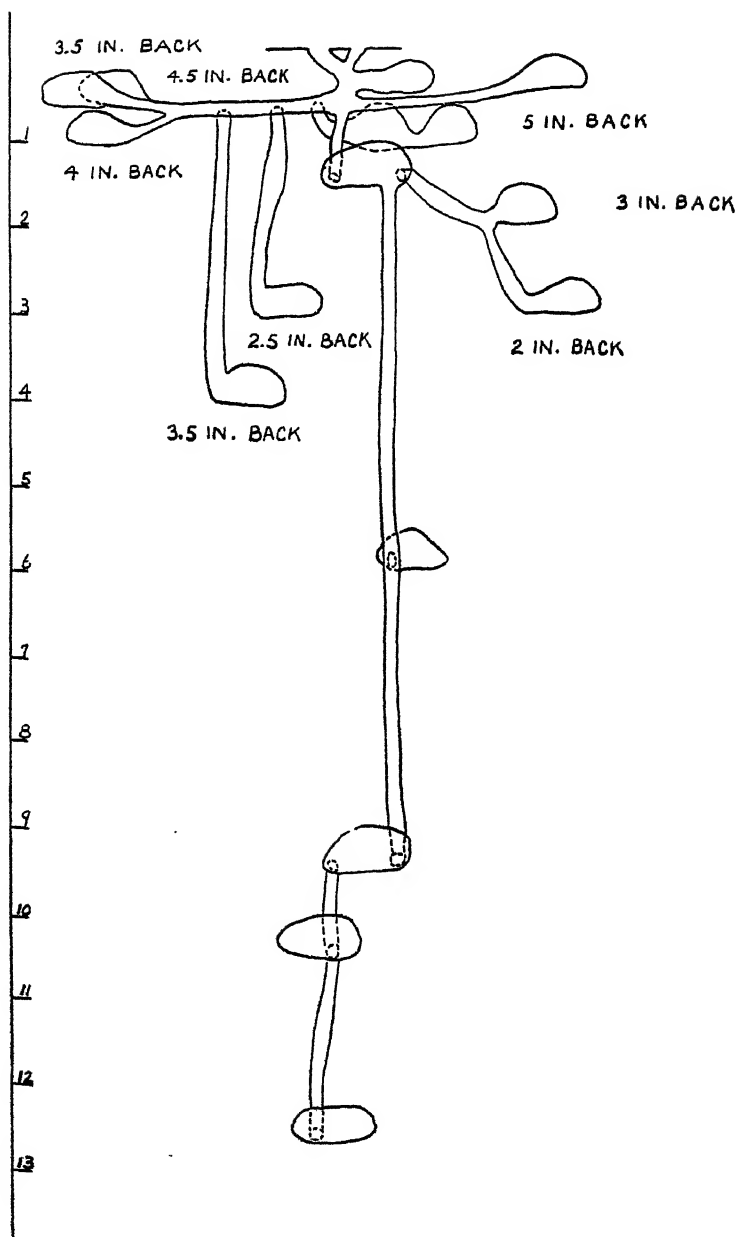


FIG. 2. A large nest of *Aphaenogaster fulva aquia*.

ground and chambers were constructed in the decaying wood. One complete colony was found in the upright living stem of tall blue lettuce (*Lactuca spicata*). (This plant was common in the locust woods, grew from five to seven feet tall and had a hollow stem one-half to three-fourths of an inch in diameter). The nest opening was a round hole a foot from the ground and above this was a series of semicircular platforms which seemed to have been constructed by the ants and upon which the brood rested. Three colonies were found nesting in hollow dead stems as they lay upon the ground. The broken ends were plugged

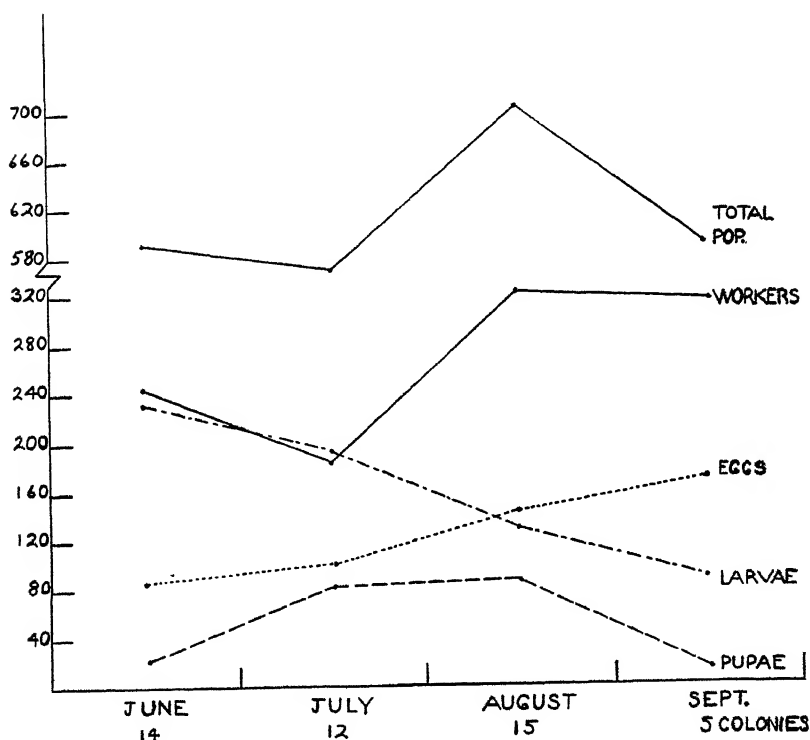


FIG. 3. Means of developmental stages of *Aphaenogaster fulva aquia* during the summer months.

with pellets of debris and entrances were made in the sides. Food was brought in through the entrances and the entire colony, including the queen, lived in the stem.

Other colonies combined these hollow stems with regulation underground nests by using them as above-ground chambers into which pupae and large larvae were brought for speeding up development in a warm dry place. A variety of hollow stems such as nettle, ragweed, elderberry and tall blue lettuce was available for this function. Sometimes the stems were just above the nest entrances but sometimes the ants carried brood for three or four inches to a suitable stem. More fragile above-



ground chambers were made of curled-up leaves. Sometimes brood was simply piled between leaves and layers of small twigs which lay above the nest entrance. These above-ground chambers, of whatever nature, seemed to be quite temporary and ants were constantly bringing brood to them or carrying it away. Colonies living in stems must have to move frequently because stems are often crushed or displaced, or stems may be summer homes for colonies which will move underground before winter. The tendency to live above ground seemed most conspicuous during wet periods when the ground was soaked.

One colony utilized a root, as well as a bit of stem, for its nest (Figure 1). In this instance a very short piece of stem was attached to a root which was bulbous at the ground surface and then extended down for five inches as a narrow gallery-size tube. The ants used the short stem as an above-ground chamber and filled it with pupae. They had hollowed out the bulbous portion of the root into four chambers and used the rest of the root as a gallery. Extending out from it were three chambers excavated in the soil and a secondary gallery from which radiated two more chambers.

The ants were apt to use natural crevices in the soil instead of doing their own digging. Since earthworm holes were very common, the ants frequently adopted one and used it as a gallery around which they constructed chambers. These wormhole galleries could be recognized because they were larger in diameter and smoother than galleries which the ants dug for themselves.

*Populations.*—Colonies in the locust woods were numerous but not large (Table I). (Farther north, along the shore of Lake Erie, I have found habitats where *Aphaenogaster* were abundant under stones and where colonies seemed consistently two or three times as large). The mean population for the 46 colonies was 656.66. These averaged 280.47 workers, 63.28 pupae, 182.43 larvae and 120.83 eggs. No first-year colony was found; the smallest consisted of 58 individuals of which 20 were workers. The largest colony found was made up of 1440 individuals of which 950 were workers. This colony was one of two found which had two queens.

Since similar studies were made of two species of *Leptothorax* (Headley, 1943) it may be interesting to compare populations of these three myrmicine ants.

	Number of Colonies	Mean Population	Range	Mean of Workers
<i>A. fulva aquia</i> .....	46	656.66	58-1440	280.47
<i>L. curvispinosis</i> .....	38	235.00	31-727	82.6
<i>L. longispinosus</i> .....	97	135.90	7-419	45.8

The make-up of an ant colony varies during the season with the maturing of brood (Figure 3). A nest dug November 20, 1947, revealed that this species overwinters, not only as larvae, but also as eggs. The count for that colony was 880 workers, 519 larvae and 647 eggs. The overwintered larvae become the year's first callow workers and also seem responsible for all of the males and females produced. When digging began, during the first week of June, there were as yet no pupae but they were present by June 10 and remained as a part of the population from then on, reaching their height in July and August. Egg

TABLE I

POPULATION DATA, COLONIES OF *Aphaenogaster fulva aquia*, LOCUST WOODS

Date	Winged Worker Male Female									
	Queen	Workers	Males	Females	Pupae	Pupae	Pupae	Larvae	Eggs	Total
6- 6-47	1	130	.....	.....	.....	.....	.....	.....	25	156
6- 6-47	1	31	.....	.....	.....	.....	.....	21	51	104
6-10-46	1	490	.....	.....	.....	.....	.....	316 <sup>1</sup>	255	1062
6-10-47	1	410	.....	.....	16	.....	.....	139	40	606
6-11-46	1	117	.....	.....	31	.....	.....	174	108	431
6-11-46	0	131	.....	.....	.....	.....	.....	91 <sup>2</sup>	23	245
6-12-46	1	48	.....	.....	1	.....	.....	99	64	213
6-12-46	1	418	.....	.....	34	.....	.....	387	112	952
6-16-47	0	298	.....	.....	17	.....	.....	140	22	477
6-18-45	1	456	.....	.....	.....	.....	.....	351	55	873
6-21-47	1	296	.....	.....	38	.....	.....	426	124	884
6-21-47	1	185	.....	.....	70	.....	.....	394	107	757
6-24-46	1	167	.....	.....	69	.....	.....	410	107	754
6-26-47	1	246	.....	.....	44	15	1	336	157	800
7- 1-47	1	43	.....	.....	30	.....	.....	80	79	233
7- 1-47	1	11	.....	.....	12	.....	.....	72	42	138
7- 1-47	0	138	.....	.....	6	6	.....	67	77	294
7- 3-47	1	224	.....	.....	59	32	.....	418	137	871
7- 3-47	0	119	.....	.....	35	6	.....	122	28	310
7- 3-47	1	20	.....	.....	3	.....	.....	18	16	58
7-19-46	1	174	.....	.....	28	.....	.....	48	173	324
7-19-46	1	255	.....	.....	172	.....	.....	211	235	874
7-20-46	1	285	15	.....	91	24	.....	275	119	810
7-22-46	1	356	.....	.....	275	.....	.....	449	56	1137
7-23-46	1	219	.....	.....	66	.....	.....	306	99	691
7-31-46	1	384	11	2	219	.....	.....	248	150	1015
8- 5-47	1	204	.....	.....	224	.....	.....	303	132	864
8- 7-46	1 <sup>3</sup>	193	52	16	23	.....	.....	7	0	292
8-14-46	1	258	.....	.....	93	.....	.....	118	268	738
8-21-46	1	154	.....	.....	36	.....	.....	84	193	468
8-23-47	1	146	.....	.....	41	.....	.....	61	81	330
8-23-47	1	652	.....	.....	145	.....	.....	232	191	1221
8-25-47	1	275	.....	.....	51	.....	.....	80	92	499
8-26-46	0	328	3	.....	58	.....	.....	39	41	469
8-27-47	1	242	.....	.....	62	.....	.....	73	82	460
8-27-47	1	299	.....	.....	88	.....	.....	174	336	898
8-27-46	2	38	.....	.....	0	.....	.....	10	12	62
8-27-46	1	509	.....	.....	121	.....	.....	76	163	1070
8-29-45	1	720	17	.....	242	.....	.....	169	231	1380
8-30-45	1	538	.....	.....	151	.....	.....	84	324	1098
8-31-45	1	277	.....	.....	8	.....	.....	453	39	778
9- 2-44	0	357	.....	.....	2	.....	.....	52	149	560
9- 4-44	2	950	.....	.....	9	.....	.....	161	322	1440
9- 8-47	1	74	.....	.....	12	.....	.....	119	91	297
9- 8-47	1	30	.....	.....	18	.....	.....	17	44	110
9- 8-47	1	180	.....	.....	30	.....	.....	110	248	569

<sup>1</sup>Eight were female larvae.<sup>2</sup>Fourteen were female larvae.<sup>3</sup>Dead but still lying in the nest.

laying continued uninterrupted throughout the summer. Larvae were at their peak in June as a result of an accumulation of overwintered larvae plus those from overwintered and spring laid eggs. Workers did not reach their full strength until August when these larvae had had time to pupate and emerge. Young workers developed pigment rapidly and there were never many callows in the nest. Figure 3 shows the relative abundance of the developmental stages during the summer.

Since workers must forage for and feed the larvae, as well as themselves, it was thought of interest to compare the relative abundance of these two stages. In June there were 1.09, in July only 0.96, and in August 2.46 workers for every larva. Through the summer the colonies showed slightly more brood (eggs, larvae, pupae) than workers. In June there were 1.40 brood per worker, in July 2.03, and in August 1.14. If many more young than adults means rapid growth in a population then it would seem that *Aphaenogaster fulva aquia* colonies increase in size rather slowly.

Also the number of colonies does not increase rapidly, if meagerness of winged forms can be taken as an indication. In spite of the fact that, during three seasons, 36 colonies were dug within the time when males and females might have been expected, only 11 colonies possessed them. Development of the winged ants spread over the summer. Male larvae could not be distinguished but female larvae were recognizable by June 10 because of their large size. The first male and female pupae were found on June 26 and adult winged ants did not emerge until the latter part of July. No flights were seen but it is assumed that they occur in August.

#### SUMMARY

Forty-six colonies of the ant *Aphaenogaster fulva aquia* were studied during June, July and August in a small locust woods in Seneca County, Ohio. Nest structure showed great variation and versatility in using various materials. Most nests were excavated in the soil and consisted of one to four galleries extending 1 to 34 inches deep, from which radiated 2 to 17 chambers, but some colonies nested above ground under bark of standing trees, in hollow stems or simply among the leaves and twigs which covered the ground. Many nests had one or two above-ground chambers combined with the below-ground ones. The ants often utilized hollow roots, earthworm holes and natural crevices.

Populations were not large, ranging from 58 to 1440 individuals with a mean population of 656.66. Eggs and larvae were overwintered and pupation began early in June, but workers did not reach full strength until August. Males and females apparently developed from the overwintered larvae and emerged as adults during the latter part of July.

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# THE GENERIC IDENTIFICATION OF NEARCTIC REDUVIID NYMPHS

(Hemiptera)<sup>1</sup>

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The senior author in December, 1933, began the accumulation of a series of notes as to the structure of the nymphs of Reduviidae with the hope of arranging a synopsis which would aid in the identification of unknown immature members of this family. The material consisted of the collections of the United States National Museum.

Many of the genera of Reduviidae occurring in the United States are represented by nymphs in this collection, although the reliability of the identification varies considerably. Very few of the specimens have been reared from the eggs laid by known females, the only way of securing positive identification. Some of the nymphs have been so characteristic that they have been determined by their resemblance to adults, while others have apparently been determined on the basis of the adult Reduviidae which were found in the immediate vicinity, perhaps on the same day.

The completed manuscript which resulted from the above-mentioned work was referred to the junior author in 1947. The junior author checked the basic keys against material in his own collection and in the collection of the California Academy of Sciences. Many additions and corrections were made as a result of this study. This paper is thus a joint effort based upon examination of the nymphs of four-fifths of the genera of Reduviidae known to occur in the United States.

The need for a special key for the identification of nymphs and apterous adults is due to the fact that the characters used for the separation of the winged adults into subfamilies and groups of genera (Fracker, 1912) are not always available in the wingless forms. These characteristics include the presence, absence, or relative position of the ocelli, the nature of the venation of the hemelytra, the transverse division of the pronotum (the pronotum of the nymphs not being so divided), and the presence or absence of a tubercle on the side of the mesothorax adjoining the pronotum. The absence of these characters in the nymphs makes it impossible to trace them through any published keys.

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After a series of notes had been accumulated, it became clear that, to a large extent, the same subfamily groups could be delimited on the basis of characters present in the nymphs and not heretofore recorded or used by hemipterists, and that these new characters proved in most cases to be constant through all the available material from the first stage nymphs to the adults themselves. Unfortunately, a number of the genera are not represented by nymphs in our collections and a synopsis based solely on the available material would accordingly show certain gaps. In tracing a specimen through such a key and finding that it complied with the description of a certain genus, one would feel uncertainty as to whether it might not belong to one of the other genera in the same group. After considerable thought and study it was decided that the needs of entomologists would best be served by including such closely related genera and showing those characters which were present in the adults and which observation had indicated might be constant throughout the entire life cycle of the insect.

The synopsis presented later in this paper, therefore, consists of an arrangement of the genera of Reduviidae, under which it is hoped that any specimens of nymphs or adults of the United States may be placed in their proper genera. Those genera in which nymphs have been studied are indicated by an asterisk.

It should be understood that the characters used apply in many cases only to genera and species found in North America. One of the best examples of the significance of that fact is the subfamily *Apiomerinae* which was erected by Stål to include a group of genera which have their ocelli farther apart than the eyes. No nymphs of this subfamily were available except those belonging to the genus *Apiomerus*, the only genus occurring in North America. The subfamily character given in this paper accordingly uses the peculiar shapes of the tarsi and tibiae which characterize the latter genus but not the more tropical genera of the subfamily.

The writers have been interested in some of the theoretical implications of the observations here reported. It was thought that the nymphs in developing through their successive instars would probably show changes by means of which new light would be thrown on the relationships of the different genera and subfamilies. The writers were somewhat surprised to discover, therefore, the constancy with which these new characters, particularly the relative lengths of the segments of the antennae and beak, the shape of the coxae, and the number and position of the dorsal abdominal scent glands, (Readio, 1927, and Usinger, 1943), were retained throughout the nymphal period of development. At the present stage of observation, we are unable to add any new contributions to the relationship of the members of this family to each other. The only grouping which broke down completely and which was not confirmed by any character of the nymphs yet discovered, was the division of the subfamily Harpactorinae into two tribes on the basis of the presence or absence of the mesothoracic tubercle mentioned above.

A synopsis of the subfamilies and genera of the nymphs and adults of the Reduviidae of the United States prepared on the plan above outlined follows.

## KEY TO THE GENERA OF REDUVIIDAE OF THE UNITED STATES

- 1 (18) Anterior coxae elongated, usually at least four times as long as wide and usually extending well beyond apex of head. . . . . **EMESINAE**
- 2 (15) Fore tarsi distinctly segmented, sometimes heavily sclerotized and the segments subfused, but the dividing sutures always visible under a high-power lens; claws of fore tarsus consisting of an equal-sized pair (except in some species of *Ploiaria*).
  - 3 (4) Fore femora without distinguishable ventral spines or bristles, only fine hairs; third antennal segment as long as second and about three times as long as fourth. . . . . **Emesopsis**
  - 4 (3) Fore femora with distinct spines or bristles on ventral surface which are readily distinguishable from any fine hairs which may be present (except in some species of *Empicoris*); third antennal segment not nearly so long as second and frequently shorter than fourth.
    - 5 (12) Ventral spines on fore femur commencing at or very close to base; fore tibia very distinctly over half as long as fore femur.
      - 6 (7) Prothorax with a deep constriction, distinctly bilobate, pedunculate, the nymphs without posterior enlargement over mesonotum but still pedunculate, strongly widened anteriorly. . . . . **Stenolemus**<sup>2</sup>
      - 7 (6) Prothorax not as above, never more than slightly constricted.
      - 8 (9) Fore tarsus long, about half as long as tibia, heavily sclerotized and bare above, the segments fused so closely that the oblique sutures are visible only under a very high power lens. . . . . **Ploiaria**\*
      - 9 (8) Fore tarsus very short, much less than half as long as tibia, not heavily sclerotized and not bare above, the segmentation distinct.
    - 10 (11) First segment of rostrum long, reaching to eyes, longer than second or third segment and over half as long as second and third segments together; adults with two-segmented fore tarsi. . . . . **Empicoris**\*
    - 11 (10) First segment of rostrum shorter, not reaching to level of eyes, much shorter than second or third segment and less than one-fourth as long as second and third together; adults with fore tarsi three-segmented, . . . . . **Lutevopsis**
  - 12 (5) Ventral spines on fore femur commencing at or near the middle; fore tibia not or but little over half as long as fore femur.
    - 13 (14) Fore tibia about half as long as fore femur; basal ventral spine of fore femur not longer than the longest of the others; fore tarsus with the segments well defined, not heavily sclerotized, hairy above. . . . . **Gardena**\*
    - 14 (13) Fore tibia not nearly half as long as fore femur; basal ventral spine of fore femur very distinctly longer than the longest of the others; fore tarsus with the segments poorly defined, heavily sclerotized, bare above. . . . . **Emesaya**\*
  - 15 (2) Fore tarsi without distinguishable segmentation under the highest power lens, consisting of but one heavily sclerotized segment with an unequal pair of claws, a single claw, or without distinct claws.
    - 16 (17) Fore tarsus with two longitudinal series of angularly deflected spines; labrum closely adherent to base of rostrum, not projecting spine-like, . . . . . **Ghilianella**\*
    - 17 (16) Fore tarsus with two series of setulose hairs on its ventral surface; labrum projecting spine-like above base of rostrum. . . . . **Metapterus**\*
  - 18 (1) Anterior coxae shorter, not more than twice as long as broad and not extending beyond apex of head.
    - 19 (22) Second segment of beak angularly dilated at middle and armed above with a pair or tuft of stiff setae; second antennal segment much shorter than first; no ocelli in either adults or nymphs. . . . . **SAICINAE**
    - 20 (21) Pronotum armed with spines; prothorax with porrect prolongation on each side below. . . . . **Saica**\*
    - 21 (20) Pronotum unarmed (at least in adult); prothorax without porrect prolongations below. . . . . **Oncerothochelus**

<sup>2</sup>*Stenolemoides* M. & M. has been raised from subgenus to genus (Wygodzinsky, 1946). Adults differ from *Stenolemus* in that the posterior lobes of head and pronotum lack tubercles.

- 22 (19) Second segment of beak cylindrical or slightly spindle-shaped, not angularly dilated and armed above.
- 23 (58) Second segment of antennae about one-fourth longer than first; latter often thickened and shorter than anteocular part of head.
- 24 (29) Anterior coxae about twice as long as wide, subcylindrical except for flattened lateral surface, nearly half as long as femora; second antennal segment about twice length of first; first segment of beak shorter than second..... **PIRATINAE**
- 25 (26) Middle tibia without spongy fossa; head long, porrect; no lateral tubercles on neck..... **Sirthenia\***
- 26 (25) Middle tibia with spongy fossa; head short, deflexed.
- 27 (28) Anterior tibia abruptly dilated in apical half, inner apical margin of femur opposite slender basal half of tibia with numerous short, stiff spines in addition to long bristles..... **Melanolestes\***
- 28 (27) Anterior tibia not abruptly dilated at middle, inner apical margin of front femur without short, stiff spines..... **Rasahus\***
- 29 (24) Anterior coxae about as long as wide, globose or conical, scarcely one-fourth as long as femora.
- 30 (33) Antennae with second segment composed of numerous subsegments; nymphs with basal segment of posterior tarsi usually half as long as apical..... **MICROTOMINAE**
- 31 (32) Body hairy, hairs of legs as long as femora are thick; head short, not produced in front of antenniferous tubercles..... **Homalocoris\***
- 32 (31) Body not noticeably hairy, hairs shorter; head long, produced in front of antenniferous tubercles..... **Microtomus\***
- 33 (30) Antennae with second segment not composed of subsegments; nymphs with basal segment of posterior tarsi usually about one-fourth as long as apical.
- 34 (35) No spiracular orifices visible on mesothorax of nymphs; scutellum when visible with apex bifurcate or trifurcate; abdominal scent gland openings at base of fifth and sixth segments,<sup>3</sup>
- ECTRICHODIINAE, Rhiginia\***
- 35 (34) Spiracular orifices visible and well developed on mesothorax of nymphs; adults with apex of scutellum rounded or pointed; abdominal scent gland openings not as above.
- 36 (43) Abdominal scent gland openings on fourth, fifth, and sixth segments, or absent; second segment of beak usually longer than first.
- 37 (40) Head strongly produced cephalad, not deflexed at tip; antennae inserted on sides; beak straight, close to ventral side of head throughout length; abdominal scent gland openings absent..... **TRIATOMINAE**
- 38 (39) Body naked or with short pubescence, the individual hairs shorter than spaces between hairs; pubescence of appendages shorter than thickness of appendages..... **Triatoma\***
- 39 (38) Body clothes with long pubescence, the individual hairs longer than spaces between hairs; pubescence of appendages longer than thickness of appendages..... **Paratriatoma\***
- 40 (37) Head deflexed, beak curved, usually not close to ventral side of head throughout length; abdominal scent gland openings sometimes small but present on fourth, fifth, and sixth segments..... **REDUVIINAE**
- 41 (42) Body nearly naked (adults)..... **Pseudozelus\***
- 42 (41) Body densely hairy..... **Reduvius\***
- 43 (36) Abdominal scent gland openings on fourth and fifth segments; second segment of beak usually shorter than or subequal to first,
- STENOPODINAE**
- 44 (49) Head armed with a furcate spine below on each side behind the eyes.

<sup>3</sup>In counting abdominal segments in adults, the first segment which is reduced to a small dorsal plate should not be overlooked. Dorsal abdominal scent gland openings are conspicuous and functional in nymphs. They are inconspicuous but still present in adults.

<sup>4</sup>*Zeluroides* Wygodzinsky (1948) is recorded doubtfully from the United States (Arizona ?). Adults differ from *Reduvius* and *Pseudozelus* in that the fore and middle femora are spined and the body surface is granular.

- 45 (46) First segment of antenna incrassate, apex produced in a spine beyond insertion of second segment. . . . . **Phorontis\***
- 46 (45) First segment of antenna not produced beyond the insertion of second segment.
- 47 (48) Apex of head at base of rostrum unarmed; first segment of rostrum extending caudad of eyes, nearly twice as long as the two apical segments together; fore femora unarmed. . . . . **Pygolampis\***
- 48 (47) Apex of head produced into a short, porrect obtuse spine on each side at base of rostrum; first segment of rostrum extending to caudal margin of eyes, subequal in length to the two apical segments together; fore femora with a double series of short spines below. . . . **Gnathobleda\***
- 49 (44) Head unarmed below or armed with a simple spine, rarely a subfurcate spine at base.
- 50 (53) Antecular part of head two or three times as long as postocular, nearly twice as long as wide; fore femora armed with a row of short spines or tubercles beneath.
- 51 (52) First segment of beak one-third longer than second; head subcylindrical, the sides of anterior lobe subparallel. . . . . **Stenopoda\***
- 52 (51) First and second segments of beak subequal; head relatively broad, the sides of anterior lobe rounded. . . . . **Oncocephalus\***
- 53 (50) Antecular part of head about as wide as long, not over twice as long as postocular part.
- 54 (55) Fore femora swollen, armed with short spines beneath, longest near base. . . . . **Ctenotrachelus\***
- 55 (54) Fore femora not swollen, unarmed.
- 56 (57) Head not produced in front of antenniferous tubercles, antecular part a little longer than postocular. . . . . **Diaditus**
- 57 (56) Head produced in front of antenniferous tubercles, antecular part twice as long as postocular. . . . . **Narvesus**
- 58 (23) Second segment of antennae subequal to or much shorter than first.
- 59 (60) Anterior tarsi minute, retractile within a groove of the greatly swollen tip of the anterior tibiae; first and second antennal segments subequal, with minute spherical subsegment between successive principal segments; beak with second segment several times as long as first, . . . . . **APIOMERINAE** **Apiomerus\***
- 60 (59) Anterior tarsi not minute and retractile within tip of tibiae, latter never greatly swollen at tip; first antennal segment much longer than second, over twice as long except in *Rhynocoris*. . . . . **HARPACTORINAE**
- 61 (64) Second segment of beak at least 1.5 as long as first, usually nearly double the length of the first.
- 62 (63) First segment of antennae nearly twice as long as head. Anterior femora longer than posterior. . . . . **Zelus\***
- 63 (62) First segment of antennae about as long as head. Anterior femora shorter than posterior or subequal. . . . . **Rhynocoris\***
- 64 (61) Second segment of beak subequal to or shorter than first.
- 65 (80) Anterior femora not armed with spines.
- 66 (69) Head behind bases of antennae with blunt elevations but without distinct dorsal spines.
- 67 (68) Pronotum with antero-lateral angles armed with a subacute process; legs annulate, black and yellow. . . . . **Psellioopus\***
- 68 (67) Pronotum with antero-lateral angles rounded; legs not with numerous annulae, occasionally with one or two rings. . . . . **Castolus**
- 69 (66) Head bearing a distinct dorsal spine behind each antenna.
- 70 (71) Lateral angles of next to the last abdominal segment each armed with a spine. . . . . **Atrachelus**
- 71 (70) Lateral angles of abdominal segments not armed or with small spines on anterior segments only.
- 72 (77) Pronotum armed with four dorsal spines on the disk.
- 73 (76) Head as seen from the side gradually narrowed into a neck.
- 74 (75) (Adults with a tubercle or fold on the mesosternum in front, tubercle scarcely distinguishable in nymphs). . . . . **Heza\***



- 75 (74) (Adults without tubercle or fold on the mesosternum in front). . . . *Rocconota*<sup>5</sup>  
 76 (73) Head as seen from the side suddenly constricted into a neck. . . . *Repipta*\*  
 77 (72) Pronotum sometimes with spines or tubercles at lateral angles but none on the disk.  
 78 (79) Postocular part of head about half longer than antecular, gradually narrowed to base from both dorsal and lateral views. . . . *Arilus*\*  
 79 (78) Postocular and antecular parts of head subequal; former with sides almost parallel to base, lateral view showing pronounced dorsal constriction in basal fourth. . . . *Fitchia*\*  
 80 (65) Anterior femora armed with spines at least at the apex.  
 81 (84) Femora each with a pair of spines at the extreme apex.  
 82 (83) Head as seen from the side gradually narrowed to base. . . . *Ricolla*\*  
 83 (82) Head as seen from the side suddenly constricted at base. . . . *Doldina*\*  
 84 (81) Femora not with a pair of spines at the apex.  
 85 (86) Anterior tibiae armed with long spines. . . . *Sinea*\*  
 86 (85) Anterior tibiae unarmed. . . . *Acholla*\*

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<sup>5</sup>A nymph believed to be *Rocconota annulicornis* traces to *Arilus* in the synopsis; it is distinguishable by the beak, since in *Rocconota* the first and second segments are equal, while in *Arilus* the second is at least one fourth shorter than the first.

THE WAYS OF A MUD DAUBER, by GEORGE D. SHAFER. xiii+78 pages, 10 plates, 9 text figures. Stanford University Press. 1949. Price, \$2.50.

The J. H. Fabre style of writing is unfortunately too uncommon in this age of experimental science, in which rigid competition for space and the need for exactness of expression too often lead to an uninteresting, stereotyped style. A few, like W. M. Wheeler, the Peckhams, the late Phil Rau, and Australia's Tarleton Rayment have succeeded in preserving individual readable styles in which to transmit their scientific contributions. These contributions, however, like Fabre's, were mainly in the field of descriptive science. When, on the other hand, an experimental worker, a physiologist retiring from college teaching, turns to observations of the behavior of wasps, but carries over into his descriptive tasks something of the work habits of his previous research, the results are especially interesting.

Dr. Shafer has produced a very readable book that may be enjoyed by the professional entomologist and the non-professional alike. Some parts of it have definitely the Fabre touch; for example, the description of the antics of the "mud dauber of the window," who became such a pet that she bothered the scientist by begging for attention at most inopportune times, or the account of Crumple-Wing, the crippled wasp which he was able to study at close range in her bell-jar home in the laboratory. On the other hand, the discovery of the way in which the uric acid accumulation of the larva is eliminated, though told in the same interesting way, shows the physiologist at work.

The book is based on five years' observations. The original contributions contained in it should not be overlooked by the student of insect behavior or by the arthropod physiologist.—M. T. J.

## THE NORTH AMERICAN SPECIES OF PARAGNETINA (Plecoptera, Perlidae)<sup>1</sup>

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The writer considers the subfamily Perlinae to include the Perlidae which have the male subanal lobes little modified (not produced into sharp hooks), which have the tenth tergite cleft and the posterior angles of the cleft thickened and produced into forward-pointing processes or "genital hooks," and which have three normal ocelli (Ricker, 1943). A systematic review of the subfamily is badly needed, but since the species are mostly Old World ones, it will probably be done by a student having good access to such material. However, the Old World species currently included in *Perla*, having rather large, simple genital hooks, seem sufficiently different from all American species that the latter should not be included in the type genus. Another fairly distinct group is *Neophasganophora* Lestage (*Phasganophora* Klapálek), which has a single species in America. There is a considerable number of species, including the five discussed in this paper, in which the genital hooks have a large callus or shield ("Schwiele") on the inner side. Whether all such species should be included in one genus is debatable; if so, the genus would include most or all of the species ascribed by Klapálek (1923) to *Paragnetina*, *Tylopyge*, *Togoperla* and *Banksiella*. Whether or not one inclusive genus of this extent should be recognized, the five American species seem to be best contained in a single genus. The genital hooks of all are rather short, not cleft at the tip, and have the callus well developed. They all have a median backward-pointing lobe on the male eighth tergite, though this is quite small in *kansensis*. In the female, all five species have the subgenital plate slightly to moderately produced, and bearing a small median notch or excavation. Variety appears in the presence or absence of a posterior extension of the male fifth tergite, excavated or bifid at the tip: this is present in *media*, *immarginata* and *fumosa*, but absent in *kansensis* and *fattigi*. The type species of *Paragnetina* also has such a process. At a subgeneric level a separation of the species lacking it from those which have it would probably be useful, but the matter should be left for a comprehensive revision of the group. Currently our five species are involved in an annoying confusion of specific and generic nomenclature.

### *Togoperla* Klapálek

1907. *Togoperla* Klapálek, Rozpr. Česká Akad. 16 (31): 19 (subgenus of *Perla*).

The use of this name in America was apparently first proposed by Needham and Claassen (1925, p. 286) by inserting it as a subgenus of *Perla* in the list of species at the end of their work, to contain the species *immarginata* Say and *media* Walker. Frison (1935) accepted

<sup>1</sup>Contribution No. 364 from the Department of Zoology, Indiana University, Bloomington, Indiana.

it as a genus to contain the same two species, and also a "species A" later identified as *kansensis* Banks (Frison, 1937). It is impossible to speculate on what factors influenced these authors in choosing *Togoperla* as a name for our species, for they have not discussed the matter. However, it does not seem to be a good choice. In 1907 Klapálek described as subgenera both *Togoperla* and *Paragnetina*, the latter a page or two earlier in the paper. In Klapálek's (1923) monograph of the family both names are treated as genera. The type species of *Togoperla* is *limbata* Pictet, and the type specimen is evidently a female (MacLachlan, 1875). Its subgenital plate is greatly produced, covering the ninth and tenth sternites, and this has no parallel among American species. Also, the genital hooks of male *limbata* as illustrated by Klapálek are not at all close to those of any American species. Thus the use of *Togoperla* in America rests on considerable uncertainties of association, and should be abandoned in favor of the completely eligible *Paragnetina*.

### Paragnetina Klapálek

1907. *Paragnetina* Klapálek, Rozpr. Česká Akad., 16 (31): 17 (subgenus of *Perla*).

The type species, *Perla tinclipennis* MacLachlan from Japan, is illustrated by Klapálek (1923, p. 69). The figure of the female answers well to MacLachlan's description of the type female, and both the male and the female of Klapálek's drawings are very similar to our species *immarginata*, though of course not so close as to suggest specific identity. It is evident therefore that *Paragnetina* is much the best choice of a generic name for American species. When the structure of the type species of *Togoperla* is certainly established, that name may either become a synonym of *Paragnetina*, or may remain in use for a series of species more or less different from the American ones—depending partly on the revisor's tastes.

### Banksiana Claassen

1936. *Banksiana* Claassen, Ann. Ent. Soc. Amer. 29: 622 (new name for *Banksiella* Klapálek, preocc.)

1921. *Banksiella* Klapálek, Ann. Soc. Ent. Belg. 61: 147.

1923. *Banksiella* Klapálek, Coll. Zool. Selys-Longchamp, 4(2): 105.

The type of this genus was designated as *Perla kansensis* Banks in the original description and in 1923. However, Klapálek's specimen from which he made the generic description was not *kansensis*, but one of the species having the elongated male fifth tergite, as the description and the 1923 figure both testify. We must therefore associate the name *Banksiella*, and hence *Banksiana*, with the *immarginata-fumosa* group of species. Thus *Banksiana* becomes a synonym of *Paragnetina* Klapálek, for these species are very closely related to the type species of *Paragnetina*, *P. tinclipennis*. It may be added that even Klapálek had some doubt concerning the identity of his specimen, as shown by the fact that in 1923 the name *kansensis* was used with a query following it. I am not certain of the exact identity of the specimen figured by Klapálek in 1923 under the name "*Banksiella kansensis* (?)." It is most like *fumosa*, but the tips of the genital hooks are shown as more acute than they are in any specimens at hand.

## Eccoptura Klapálek

1921. *Eccoptura* Klapálek, Ann. Soc. Ent. Belg. 61: 60.1923. *Eccoptura* Klapálek, Coll. Zool. Selys-Longchamps 4(2): 62.

This name requires mention here because its type species, *Perla xanthenes* Newman, was based on a pair of specimens of which the female is of the species now called *Acroneuria xanthenes*, while the male is a *Paragnetina*, very possibly the *P. fattigi* described below, to judge from Klapálek's drawing. Needham and Claassen (1925) followed the practice of authors like Pictet and Hagen in diagnosing the species from the female cotype, and Frison (1942) finally designated the female as lectotype, so that the use of the name *xanthenes* can be considered settled. Regarding the name *Eccoptura*, however, Needham and Claassen (p. 194) say that it was founded by Klapálek on the secondary sexual characters of the male, and, by inference, should apply to the male rather than the female of the two cotypes. Unfortunately Klapálek nowhere appears to express this viewpoint ascribed to him by Needham and Claassen. The original description of *Eccoptura* mentions some characters common to the male and the female, and others peculiar to either sex, with no particular emphasis laid on any of them. The same is true of his key of 1923, which is primarily based on venation. Accordingly, the name *Eccoptura* is to be associated with the species *xanthenes* as now recognized. It thus has priority over *Croconeuria* Needham and Claassen (1925, p. 288), which also has *xanthenes* as type species, though current usage includes either in the genus *Acroneuria* Pictet.

## KEY TO NORTH AMERICAN SPECIES OF PARAGNETINA

## MALES

- 1a. Fifth abdominal tergite produced posteriorly (fig. 5).....2
- 1b. Fifth tergite not produced (fig. 1).....4
- 2a. Produced fifth tergite very shallowly and broadly excavated, or practically straight; genital hooks rounded at the tip.....*media*
- 2b. Produced fifth tergite narrowly and deeply notched (fig. 5).....3
- 3a. Genital hooks produced ventrally into a subacute apical spine.....*immarginata*
- 3b. Genital hooks lacking any spine, somewhat angular dorsally (fig. 4)....*fumosa*
- 4a. Seventh abdominal tergite with a tiny lobe on either side of the mid-line, posteriorly; median projection of the eighth tergite about one-fifth of the length of the tergite (fig. 1).....*fattigi*
- 4b. Seventh tergite without appendages; median posterior projection of the eighth tergite minute, about one-fifteenth as long as the tergite.....*kansensis*

FEMALES (female of *fattigi* unknown)

- 1a. Subgenital plate merely excavated; membrane of the wings tinted more alongside the veins than elsewhere.....*immarginata*
- 1b. Subgenital plate narrowly notched (fig. 2); wings light or dark in color, but not as above.....2
- 2a. Pronotum light brown with a yellow median stripe; ocellar triangle yellow or diffusely brownish.....*kansensis*
- 2b. Pronotum dark, without a yellow median stripe; ocellar triangle dark brown or black.....3
- 3a. Pronotum with black margins and black median stripe, the embossed rugosities of a chestnut color; subgenital plate little produced, the base of its median notch in a line with the sides of the hind margin of the sternite,  
*media*
- 3b. Pronotum brown, the embossed areas scarcely distinguishable from the rest in color; subgenital plate triangularly produced over nearly half of the ninth sternite, the base of its notch much posterior to the sides of the hind margin of the eighth sternite (fig. 2).....*fumosa*

*Paragnetina fattigi* new species

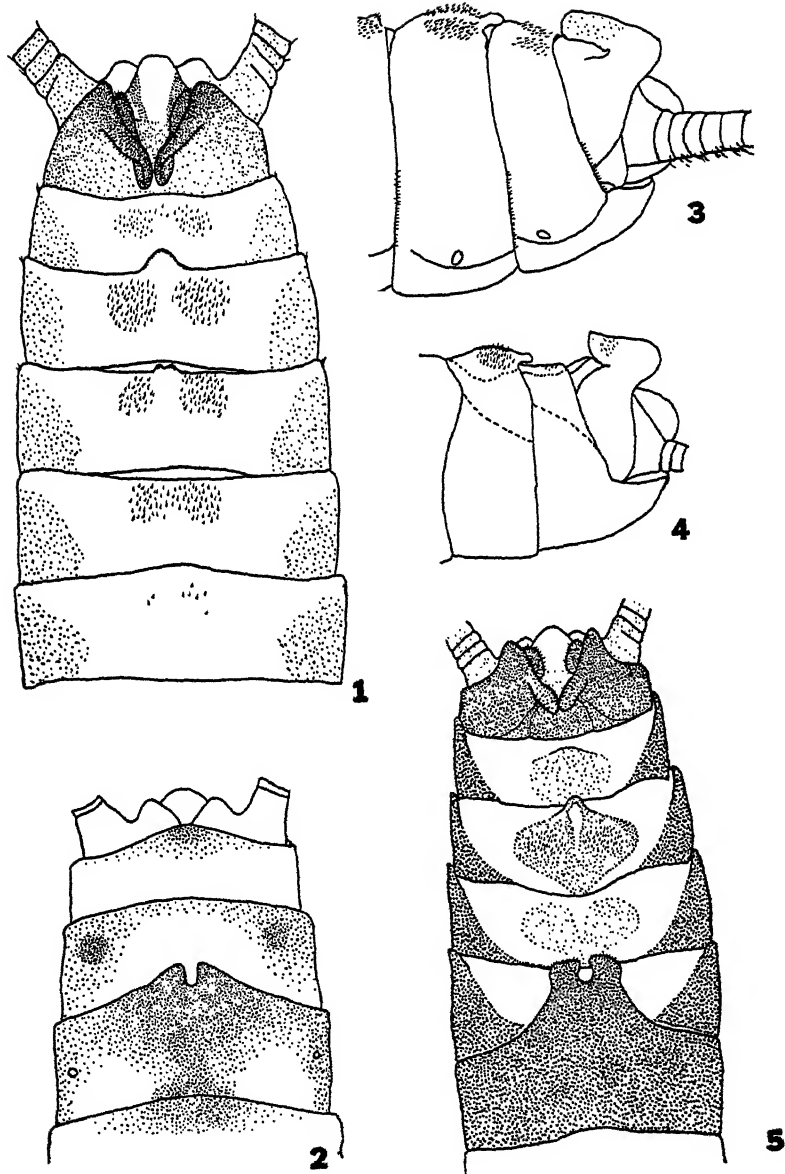
*Male*.—Length of body 14 mm., to tip of wings 19 mm. General color yellow and light brown. Head light brown, with yellowish M-line and occiput; a darker brown band connecting the anterior ocellus to each lateral one. Pronotum medium brown, the rugosities only slightly darker, the biconcave median field yellow in its posterior two-thirds. Lateral margins of the pronotum darker and bent sharply downward along an oblique line, so that in dorsal view the pronotum appears strongly narrowed behind. Metasternum with a patch of long stout dark hairs. Wings moderately and rather evenly infuscated. Costal cell crossveins four to six; other crossveins absent beyond the cord (except that in the left hind wing of this specimen there are numerous irregularities of venation).

Abdomen with patches of thickened hairs or long spinules centrally on sternites three to seven, the last-named also with shorter heavier spinules. The ninth sternite rather briefly extended posteriorly. Pleurites six to nine have each a terminal row of spinules. Tergites (fig. 1) are unmodified to the fifth, which has a very few spinules. Tergite six has a central patch of spinules posteriorly; tergite seven has two patches of spinules, and bears a pair of minute elevated lobes on its posterior margin medially; tergite eight has two patches of spinules and a median lobe posteriorly whose length is equal to one-fourth that of the sternite somewhat to its side; tergite nine has two patches of spinules (or one patch thinned out on the mid-line) and its hind margin is broadly and very slightly produced medially. The tenth tergite is cleft behind and bears the thickened lobes or genital hooks characteristic of the genus. These are spinulose on their lateral surfaces and also on the callus medially. Supra-anal process rather large, mostly membranous, but weakly sclerotized along a dorsolateral band over its entire anterior portion.

*Holotype* ♂.—Flat shoals, Concord, Georgia (Flint River, 5.5 miles west), August 1, 1945, P. W. Fattig. (In the collection of the Illinois Natural History Survey.)

This species is closely allied to *Paragnetina kansensis*, from which it is distinguished by the presence of two small lobes on the seventh tergite; by a lobe on the eighth tergite much larger than in *kansensis*; by the presence of a strong row of spinules on the hind margin of pleurites six to nine (*kansensis* has them on eight and nine, very weakly on seven, absent from six); and, in the specimen at hand, by a darker color of head and pronotum.

*P. kansensis* males have not been taken east of the Appalachians. However, two female specimens that seem to be indistinguishable from *kansensis* have been taken east of the mountains, as follows: Albany, Georgia (Flint River, 1.5 miles south), June 22, 1939, P. W. Fattig (INHS). Jackson Co., Florida (Blue Springs Creek, 3 miles east of Marianna), June 5, 1940, L. Berner (INHS). It would be tempting to regard at least the Georgia female specimen as the female of *fattigi*, since it is from the same river as the holotype. This may well prove to be the case, but both these females are much lighter in color than our *fattigi* specimen, so the association is best left undecided.



*Paragnetina falligi*. FIG. 1. Tip of abdomen of ♂ holotype, from above.  
FIG. 3. The same, from the side.  
*Paragnetina fumosa*. FIG. 5. Tip of abdomen of ♂, Cassville, Ga., June 9,  
1945; from above. FIG. 4. The same, from the side. FIG. 2. Tip of abdomen  
of ♀, Chickamuga Creek, Ringgold, Ga., from below.

The new species is named for Dr. P. W. Fattig of Emory University, Georgia, an enthusiastic and very successful collector of insects of many orders.

**Paragnetina fumosa (Banks)**

1902. *Perla fumosa* Banks, Canad. Ent. 34: 123.  
1907. *Perla fumosa* Banks, Cat. Neur. Ins. U. S., p. 11.  
1908. *Perla fumosa* Banks, Trans. Amer. Ent. Soc. 34: 256.  
1923. *Phasganophora fumosa* Klapálek, Coll. Zool. Selys-Longchamps 4(2): 96.

The following redescription of the species is from Georgia specimens, with which the types have been checked in all important characters.

*Male*.—Length of body 12 mm., to tip of wings 16–17 mm. General color dark brown and yellow. Head with the ocellar triangle, the region between the lateral tubercles and M-line, and the clypeus almost black; M-line light brown; region behind compound eyes dusky; occiput and region between ocelli and compound eyes bright yellow. Pronotum dark brown, a very narrow median stripe somewhat lighter; strongly narrowed behind. Mesothorax and metathorax mostly brown above and yellow below; a yellow stripe on the mesonotum; a patch of long stout hairs on the metasternum. Wings quite dark, strongly and evenly infuscated. Costal crossveins three to five, other apical crossveins usually absent.

Abdomen with stout hairs and spinules distributed on sternites three to five as in *P. fattigi*. Terminal spinules on pleurites seven to nine. Fifth tergite produced medially over the whole of segment six, its tip bifid and spinulose. Tergites six to nine with areas of weak sclerotization as in figure 5. Two patches of spinules on tergite eight, and a posterior median lobe; a very few spinules and a trace of a terminal lobe on tergite nine. Tenth tergite raised somewhat in front and near the midline; the genital hooks rather sharply truncate at their antero-dorsal extremity, rounded below, with small sparse spinules laterally and a larger denser group on each callus medially. Supra-anal process large, weakly sclerotized anteriorly and laterally, membranous posteriorly.

*Female*.—Length of body 17–20 mm., to tip of wings 25–28 mm. Similar to the male except in sexual characters, but usually somewhat lighter colored. Eighth sternite with the subgenital plate produced over one-fourth to one-third of the ninth sternite, with a narrow usually straight-walled median notch (fig. 2), the sides of the plate either concave, straight, or convex and sometimes angulate.

Following Needham and Claassen's synonymy of this species with *immarginata* in 1925, it does not appear to have been mentioned in the literature. Dr. Frison (manuscript notes) had studied the types, and had a few similar specimens in his collection, but considered them as a small dark southern form or race of *immarginata*. There is no question concerning the similarity of *fumosa* to *immarginata*, but there are also considerable differences: smaller size; darker, uniformly smoky wings; genital hooks without terminal ventral projections as in *immarginata*; and a more narrowly notched female subgenital plate. The general ranges of the two species are known to overlap from Virginia through Georgia (though the exact localities may not), and I have detected no overlapping in the morphological features mentioned above.

The known range of *Paragnetina fumosa* is from the District of Columbia south to Georgia and Alabama. Material examined is as follows. ALABAMA: Kushla, Mobile Co. (Seabury Creek, 1.4 miles south), June 3, 1940, ♂, L. Berner. DISTRICT OF COLUMBIA: Washington, ♂ ♀ (types). GEORGIA: Atlanta (Nancy Creek, 8 miles north), June 26, 1945, ♀, P. W. Fattig. Cassville (Clear Lake, 3.5 miles north), June 9, 1945, ♂, P. W. Fattig. Dahlonga (Caneck Falls, 3 miles north), July 31, 1945, ♀, P. W. Fattig. Forsyth (Towaliga River, 6.4 miles north), Sept. 15, 1945, ♂, P. W. Fattig. Perry (Mossy Creek, 4.6 miles north), May 13, 1939, 2♂; Sept. 7, 1945, ♂, P. W. Fattig. Ringgold (Chickamuga Creek), June 19, 1939, 2♀, P. W. Fattig. Thomaston (Whispering Pines, 12 miles south), June 8, 1939, ♀, P. W. Fattig.

### *Paragnetina immarginata* (Say)

1823. *Sialis immarginata* Say, Godman's Western Quarterly Reporter 2: 164.  
 1861. *Perla immarginata* Hagen, Synop. Neurop. N. Amer., p. 20.  
 1913. *Perla immarginata* Smith, Ann. Ent. Soc. Amer. 6: 203-211.  
 1925. *Perla immarginata* Needham and Claassen, Monogr. Plecop. N. Amer., pp. 102, 317, 329. (Description and figures of ♂ ♀).  
 1931. *Perla immarginata* Claassen, Plecop. Nymphs N. Amer., pp. 50-53, 135, 187. (Description and figures of nymph.)  
 1944. *Togoperla immarginata* Ricker, Canad. Ent. 76: 184.  
 1947. *Paragnetina immarginata* Ricker, Trans. Royal Canadian Inst. 26(2): 407.  
 1861. *Perla lurida* Hagen, Syn. Neurop. N. Amer., P. 21.  
 1909. *Acroneuria lurida* Klapálek, Bull. Internat. Acad. Sci. Boheme 18: 51.  
 1917. *Acroneuria lurida* Klapálek, Časopis České Společnosti Ent. 14: 45.  
 1923. *Perla lurida* Klapálek, Coll. Zool. Selys-Longchamps 4(2): 52.  
 1935. *Acroneuria fumosa* Ricker, Canad. Ent. 67: 262.

In deciding what species of stonefly Say described under the name *immarginata*, the usage of Smith (1913) and Needham and Claassen (1925) seems unexceptionable. Say's phrase "wings obscure, veins fuscous, immarginate" presumably means "wings somewhat smoky (not clear hyaline); the veins dark; the membrane immediately alongside the veins darker than elsewhere." This describes very well the wings of the *immarginata* of Needham and Claassen. Indeed it is difficult to think of any other species "more than an inch long" answering to this description; certainly not the *Acroneuria* placed here by Klapálek (1909, 1923; see Ricker, 1938). To confirm present usage I am selecting the following types.

Neotype ♂: Ithaca, N. Y., Sep. 9, 1889, Cornell University Collection. Neallotype ♀: The same, Sep. 28, 1907.

It should be mentioned that Banks has usually or always treated this species under the name *Perla coulunii* Pictet, as shown by a long series of specimens so labelled in the Museum of Comparative Zoology. This association of Pictet's name may well be correct, though the description is not entirely unambiguous; however, Say's name is an older one. Banks' use of *immarginata* probably refers to some *Acroneuria* which "lacks a dark eye spot."

Needham and Claassen (1925) did not distinguish *fumosa* Banks from *immarginata* Say, so either of their two southern records of *immarginata* might possibly pertain to *fumosa*. One of them I have checked and found accurate (Tallulah Falls, Georgia). Indeed none of the specimens



now in the Cornell Collection labelled *Perla immarginata* can be assigned to *fumosa*, though three females recorded by Needham and Claassen from Niagara Falls prove to be *P. media*.

Regarding Hagen's *Perla lurida*, a recent examination of the female holotype from New Orleans, in the Museum of Comparative Zoology at Cambridge, shows that it is indistinguishable from *immarginata* in color and structure of the subgenital plate. (Say's *immarginata* was known to Hagen only from the description.) The same identity of structure exists in respect to the female, also from New Orleans, determined as *lurida* by Klapálek (1909, 1923). Frison (1942) has stated that the type of *lurida* is probably the species currently being called *Acroneuria carolinensis* Banks. What suggested this is apparently the fact that the notch in the subgenital plate of the type specimen is somewhat larger than in most specimens of *immarginata*, though it is smaller than in most *carolinensis*. However, the color of the wings and their large size is sufficient to show that this type is not *carolinensis*, and the pattern of the pronotum provides additional evidence of the same. Consequently *lurida* must be regarded as a synonym of *immarginata*, unless the discovery of males from the New Orleans region will show that another closely related species is involved.

The known range of *Paragnetina immarginata* is from the James Bay region of Quebec southward and eastward through eastern Ontario, Quebec and the maritime provinces of Canada, New England, New York, western Pennsylvania, and in the hills to the Carolinas and Georgia. The New Orleans specimens mentioned above would extend this range southwestward, but a confirmation of the exact locality involved would be very desirable. Several Canadian locality records have been published in the two papers of Ricker, cited above, and others are to appear. Specimens in the Cornell University collection (CU) and the Illinois Natural History Survey (INHS) are listed below. Howell, (1939, 1941) has published records of nymphs from various localities in North Carolina.

*Material examined*.—GEORGIA: Cleveland (Chestatee River, 12 miles north), July 7, 1945, ♀, P. W. Fattig. Toccoa, July 17, 1910, ♂, J. C. Bradley (CU). Tallulah Falls, June 21, 1909, ♂, J. C. Bradley (CU). NEW YORK: Frecks, Alleghany State Park, August 11, 1926, ♂, S. C. Bishop (CU). Groton, September 5, 1928, ♂, P. R. Needham (CU). Hamilton Co., ♂, (CU). Ithaca, August 11, 1884, ♂; September 9, 1889, ♂; September 24, 1889, ♂; August 5, 1890, ♂, R. H. Pettit; August 5, 1896, ♂; September 28, 1907, ♀; July 23, 1912, ♂, R. W. Leiby; July 22, ♀, T. L. Hankinson; August, ♀; no date, ♀ (all CU). Ithaca (Fall Creek), July 15-21, ♀, F. C. H. (CU). Keene Valley, Beede's, August, ♀ (CU). Ludlowville, ♂ (CU). Mount Whiteface (2000-4000 feet), August 23, 1916, ♂ (CU). Wells, August 30, 1930, ♂ (CU). Wilmington, Essex Co., August 11, 1888, ♂; August 22, 1916, ♂ (CU). NORTH CAROLINA: No locality, ♂ (CU). Black Mts., June, 1912, ♂, Beutenmuller (CU). PENNSYLVANIA: Elk Grove, September 9, 1909, ♀; September 8, 1919, ♀; W. T. Davis (CU). Red Rock, Luzerne Co., September, 1909, ♂, W. T. Davis (CU). SOUTH CAROLINA: Oconee Co., C.C.C. Camp F2, August 22, 1936, ♂, F. Sherman (INHS). WEST VIRGINIA: Wardensville, August 14, 1930, ♂ (CU).

**Paragnetina kansensis (Banks)**

1905. *Perla kansensis* Banks, Psyche 11: 56.  
1925. *Perla kansensis* Needham and Claassen, Monogr. Plecop. N. Amer., pp. 99, 329. (Description and figures of ♂, ♀.)  
1935. *Togoperla* sp. A. Frison, Illinois Nat. Hist. Surv. Bull. 20(4): 414-416. (Description and figure of nymph.)  
1937. *Togoperla kansensis* Frison, Ibid., 21(2): 82. (Figures of ♂, ♀.)

Apparently specimens belonging to this species have always been correctly recognized, though the name has twice been applied to other species. The first of these was by Klapálek (1923), as described under *Banksiana* above. The second was by Dr. P. W. Claassen, who determined the male cotype of *Perla xanthenes* Newman, from Georgia, as *kansensis* (quoted by Ricker, 1938). The discovery of *fattigi* makes it probable that this cotype is really the latter species, but even so, Dr. Claassen's identification was eminently reasonable at the time.

*P. kansensis* is known only from Kansas, Illinois and Indiana. In addition to the Indiana and Illinois specimens listed by Frison (1937), there is in the Illinois Natural History Survey a female specimen from Douglas County, Kansas.

**Paragnetina media (Walker)**

1852. *Perla media* Walker, Cat. Neur. Br. Museum, Pt. I, p. 145.  
1861. *Perla media* Hagen, Syn. Neur. N. Amer., p. 24.  
1923. *Phasganophora media* Klapálek, Cat. Coll. Zool. Selys-Longchamps 4(2): 95. (See Ricker, 1938, for a discussion of the illustrations.)  
1925. *Perla media* Needham and Claassen, Monogr. Plecop. N. Amer., pp. 103-104, 317, 329. (Description and figures of ♂, ♀.)  
1931. *Perla media* Claassen, Plecop. Nymphs N. Amer., pp. 48-50, 157, 191. (Description and figures of nymph.)  
1935. *Togoperla media* Frison, Bull. Illinois Nat. Hist. Surv. 20(4): 327, 412-414. (Figures of ♂, ♀, nymph.)  
1938. *Togoperla media* Ricker, Trans. Roy. Canadian Inst. 22(1): 141.  
1944. *Togoperla media* Ricker, Canad. Ent. 76: 184.  
1947. *Paragnetina media* Ricker, Trans. Royal Canadian Inst. 26(2): 407.  
1935. *Acroneuria salvelini* Ricker, Canad. Ent. 67: 261.

There seem to be no taxonomic problems outstanding that concern this species. It has a chiefly northern distribution, being known from northern Saskatchewan, northern Ontario and central Quebec, south to Minnesota, Wisconsin, extreme northern Illinois, southern Michigan, central Pennsylvania and southern New England. In the Appalachians it has been collected south to Virginia and North Carolina, and Dr. H. H. Ross found it in the Ozark region of southern Missouri. It is very common in the warmer brooks and rivers of the southern Ontario uplands, but absent there from the colder of the trout streams. Canadian records can be found in the writer's papers cited above, while Needham and Claassen (1925) and Frison (1935) have United States records.

The following new United States records are from the Illinois Natural History Survey collection, determined by Dr. T. H. Frison. It has proved impossible to cite individually the numerous collections from Minnesota, Wisconsin, Michigan, and New York. The majority were collected by Dr. Frison himself or by his associates, Drs. H. H. Ross, B. D. Burks, and Carl Mohr; Drs. J. W. Leonard, F. E. Lyman, D. Denning, P. Jennings and others sent in a considerable number of specimens.

*Material examined*.—CONNECTICUT: Cornwall, Housatonic River, May 30, 1941, ♀, P. J. Jennings. Mt. Carmel (Mill River at Sleeping Giant), June 9, 1936, ♂, nymphs, K. M. & A. H. Sommerman. MARYLAND: Little Gunpowder Falls, near Jappa, nymph, T. H. Frison. Hagerstown, Marsh Run Creek, nymph, T. H. Frison. MICHIGAN: Adults from Crawford Co., June 16–17; Lake Co., June 5; Montmorency Co., July 2–15; Muskegon Co., May 29. Nymphs from the following counties of the Lower Peninsula: Benzie, Branch, Cheboygan, Gladwin, Iosco, Kalamazoo, Kent, Lake, Mason, Montcalm, Muskegon, Ogemaw, Oscoda, Otsego, Presque Isle, Tuscola; and from three in the Upper Peninsula: Delta, Mackinac, Ontonagon. MINNESOTA: Adults from Anoka Co., May 15; Hennepin Co., June 7; St. Louis Co., June 27. Nymphs from Benton, Cook, Hubbard, Lake, and Scott Counties. MISSOURI: Green Springs, Oregon Co., June 7, 1937, 4♂ 1♀, H. H. Ross. NEW YORK: Adults from Ithaca, Tompkins Co., June 10, and from Niagara Falls. Nymphs from Delaware, Dutchess, Hamilton, Livingston, Putnam, and Westchester Co. NORTH CAROLINA: Hot Springs, Madison Co. (French Branch River), June 15, 1935, 1 exuvia, H. H. Ross. Highlands, Macon Co., August, 1943, ♀, T. Howell. PENNSYLVANIA: Beavertown, Snyder Co., Middle Creek, June, 1939, 1♂, 12 nymphs, C. M. Wetzel. Monroe Co., Marshall's Creek, May 24, 1935, 1 nymph, W. J. Harmer. Stoddardsville, Luzerne Co., Lehigh River, June 4, 1938, ♀, P. Jennings. VIRGINIA: Mountain Lake, Giles Co., Little Story Creek, July 4, 1939, 5 nymphs, J. S. Rogers. WISCONSIN: Adults from Adams Co., June 5; Iron Co., Aug. 9; Lincoln Co., June 18 to July 2; Price Co., June 18; Vilas Co., July 3–22; Sawyer Co., June 30 to July 6; Washburn Co., June 5–6. Nymphs from Bayfield, Douglas, Oneida, Polk, and Waushara Counties.

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# TROMBICULID MITES AFFECTING MAN

## IV. REVISION OF EUTROMBICULA IN THE AMERICAN HEMISPHERE

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This paper is an attempt to clarify the status of the medically important chigger mites known to attack human beings in the American hemisphere. In the course of investigations on the rearing of mites causing trombidiosis of human beings, identification of the species proved to be very difficult or impossible. These species form a group having similar morphological and physiological characteristics, but they have been placed in many genera including *Trombicula*, *Eutrombicula*, *Trombiculoides*, and *Acariscus*. Many of the species of this group were insufficiently defined, and at the beginning of the writer's study 25 species had been named by Italian, Dutch, German, English, Spanish, Portuguese, French, and American authors. As a result of making collections in tropical and temperate areas, examining the type specimens of eighteen species, and rearing nine kinds in the laboratory, thirteen of the species were found to be synonyms, leaving only six recognizable species and one subspecies. These mites are placed in the subgenus *Eutrombicula* of the genus *Trombicula*. Five insufficiently described species are of uncertain status since suitable specimens were not available for study.

### Genus *Trombicula* Berlese, 1905

The genus is based on an inadequately described adult mite from Java, *Trombicula minor* Berlese (1905), which was thought to be a nymph until Willman (1941) redescribed it. The adult appears to be similar to adults of *Eutrombicula*; however, the species has not been reared or definitely correlated with any larvae. Since the majority of trombiculid mites are known only in the larval stage, the use of *Trombicula* is somewhat speculative. The genus *Trombicula* has been divided into a number of closely related genera including *Eutrombicula* Ewing, 1938. These various genera are considered here to be subgenera of *Trombicula*.

### Subgenus *Eutrombicula* Ewing, 1938

Type, *Microthrombidium alfreddugèsi* Oudemans, 1910, by original designation.

*Eutrombicula* Ewing, 1938, J. Wash. Acad. Sci. 28: 291. Radford, 1942, Parasitology 34: 66. Vitzthum, 1942, Bronns Klassen und Ordnungen des Tierreichs, Bd. 5, Abt. IV, Buch 5: 829. Ewing, 1943, Proc. Ent. Soc. Wash. 45: 57. Ewing, 1944, J. Parasit. 30: 346. Finnegan, 1945, Brit. Mus. (Nat. Hist.) Econ. Ser. 16: 14, 58. Wharton, 1945, J. Parasit. 31: 401. Taylor, 1946, Comm. Aust. Serv. 6: 147. Michener, 1946, Ann. Ent. Soc. Amer. 39: 104, 432. Ewing, 1946, J. Parasit. 32: 437. Jenkins, 1947, Ann. Ent. Soc. Amer. 40: 56. Jenkins, 1948, Amer. Jour. Hyg. 48: 22, 36.

*Acariscus* Ewing, 1943, Proc. Ent. Soc. Wash. 45: 57.—Genotype *Trombicula flui* Van Thiel, 1930. Ewing, 1944, J. Parasit. 30: 347. Wharton, 1945, J. Parasit. 31: 401. Michener, 1946, Ann. Ent. Soc. Amer. 39: 104, 432. Ewing, 1946, J. Parasit. 32: 439. Jenkins, 1949, J. Parasit. 35: 201.

The subgenus *Eutrombicula* Ewing is here redefined on the basis of both larval and adult characters.

### Larva

*Body*.—Shape evenly rounded to slightly elongated posteriorly. Length 0.15 to 0.25 mm. unengorged to 0.3 to 0.6 mm. in fully engorged specimens. Color red to reddish-orange, rarely white. Body covered with numerous transverse striae. On each side of the scutum is an ocular plate bearing two eyes. The anterior eyes are larger and have horizontal lenses; the posterior eyes are smaller and the lenses are almost vertical in position. The anus is located posteriorly on the ventral surface of the body. A dorsal and ventral view of the larva is shown in Fig. 1.

*Gnathosoma*.—Palpi with coxae and trochanters fused forming a ventral plate bearing a pair of four- to eight-branched setae. The palpal femur is rounded laterally and bears a dorsal lateral seta with three to seven branches; genu with a dorsal median seta with no to five branches; tibia with a ventral seta with no to five branches and a nude dorsal and a nude lateral seta. The tibia bears a terminal palpal claw with two prongs, of which the outer prong is the largest and longest; the inner slightly ventral prong is smaller and is located from one-half to three-fourths the length from the base. Palpal tarsus with two nude and seven plumose setae. The galeal setae are nude. The cheliceral bases are punctate dorsally. The chelicerae are flat and blade-like, concave dorsally, with a tricuspid cap at the apex; the ventral process of the cap is a narrow posteriorly directed tooth and the dorsal process appears as a flap-like process. No stigmata or tracheal trunks are found laterad to the gnathosoma.

*Legs*.—In all three pairs, each leg has seven segments which are somewhat punctate and bear setae. A pit-like urstigma lies in an excavation of coxa I near coxa II. Coxa III is removed posteriorly from coxa II. Legs I, II, and III have the coxae and trochanters each with one ventral plumose seta, basifemurs and telofemurs each with several plumose setae and no nude or specialized setae. Genua, tibiae, and tarsi each with branched plumose setae and other setae as follows. Leg I: genu with three nude setae and a short spine, tibia with two nude setae and a short spine, tarsus with a heavy curved striated nude seta, a short spine, and two nude setae, pretarsus with one nude seta; leg II: genu with one nude seta, tibia with two nude setae, tarsus with a short spine and a heavy curved striated nude seta, pretarsus with one nude seta; leg III: genu with one curved nude seta, tibia with one curved nude seta, tarsus with one long nude whip-like seta. (In *T. multi-setosa* and *T. batatas*, the tibia bears one short curved nude seta and two long nude whip-like setae; tarsus with three long nude whip-like setae.) At the apex of each leg are three claws, the central one longer and blade-like. Figures 1 and 3 show the typical chaetotaxy of the legs of the subgenus.

*Scutum*.—Size comparatively large, punctate, and more or less rectangular in shape, often with a convex posterior margin. Five barbed setae are located one at each corner and one at the anterior median position. A pair of circular sensillary bases is found in the central submedian area, from each of which arises a single flagelliform sensillum having the proximal half nude and the distal half four- to

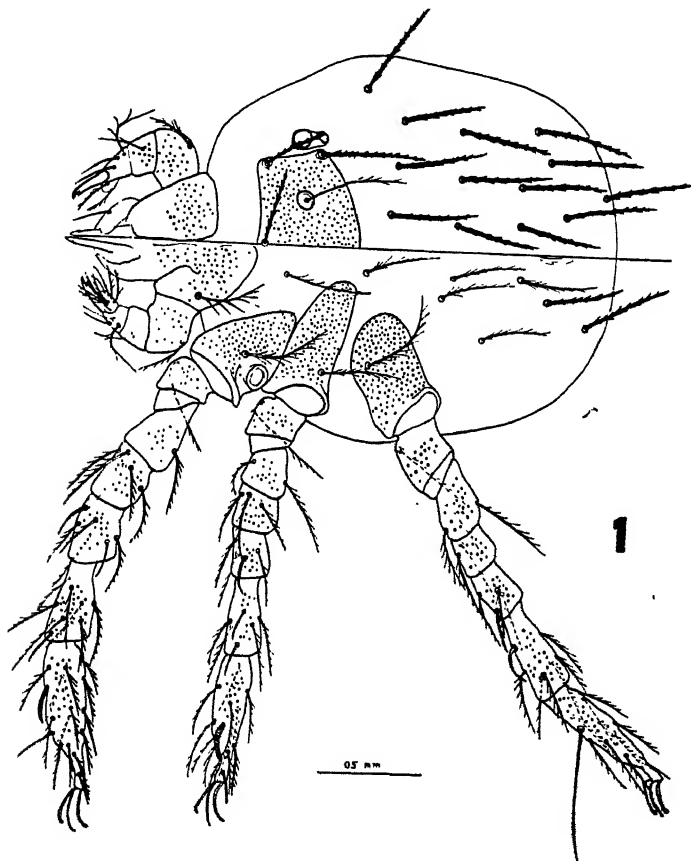


FIG. 1. Larva of *Trombicula splendens*, dorsal view above, ventral view below. (Legs rotated beyond coxae.)

nine-branched. The average standard measurements of the scutum of American hemisphere species are presented in Table I.

*Setae*.—The dorsal setae, including the humeral and posterior caudal and marginal setae, are 22 to 68 (to 54 in American species) in number, and are arranged in rows 2-12-12+, 2-10-10+, 2-8-8+, or 2-6-6+. The dorsal setae and all setae lateral and posterior to the anus are thick and barbed, 30 to 55  $\mu$  in length. The ventral setae are 14 to 46 (in American species) in number. Two pairs of sternal setae are located

between the coxae; six ventral setae are disposed roughly in the shape of an M followed posteriorly by a pair anterior to the anus, arranged as 2-2-6-2+. The ventral setae are thin, flagelliform, finely-branched, and usually shorter than the barbed dorsal setae. The thicker barbed setae of the dorsal type found lateral and posterior to the anus are counted as ventral setae since they are on the ventral surface. The body setae on the posterior surface (caudal and marginal) are counted as dorsal setae, even though their position is somewhat variable depending upon engorgement and mounting technique.

### *Adult*

*Body*.—Shaped somewhat like a figure eight, a constriction slightly anterior to the middle of the body. Length 0.7 to 1.6 mm., width 0.5 to 0.9 mm. Color brilliant red. Body densely covered with plumose setae.

*Gnathosoma*.—Palps bearing relatively few setae, femur with one inner median seta and two to four distal inner setae, tibia with a small papilla arising from the inner distal surface and bearing three strap-shaped ctenidial setae. A longer sharply pointed flat ctenidial seta arises at about the middle of the dorsal margin. Tibia with one to three setae on inner surface at tarsal articulation. Palpal claw with a rounded swelling at base of concave margin; length of claw 0.52 to 0.66 times length of tibia. Tarsus with many branched setae and with three to five or seven to fourteen simple apical setae. Chelicerae with dorsal margin serrate.

*Legs*.—Four pair of six-segmented legs, of which the anterior pair I is longest, and with enlarged tibia and tarsus. Length of tarsus I, 2.0 to 2.8 times its width, and 1.2 to 1.6 times length of tibia I. All tarsi with two claws each. Coxae I and II fused together forming a plate, coxae III and IV located more posteriorly and joined together at constriction of body.

*Scutum*.—Length of scutum 120 to 210  $\mu$  from anterior end of crista to posterior lobes of dorsal saddle over the sensillary area. Anterior to the crista is an epistome bearing one heavily branched plumose seta. The crista is slender and tube-like, broadened posteriorly into an expanded sensillary area containing a rather short median carina which extends into the crista a short distance. Lateral to the sensillary area is a pair of sensillary bases, each bearing a flagelliform sensilla 130 to 250  $\mu$  in length, and from three- to six-branched in the distal half. The width between the sensillary bases is from 38 to 74  $\mu$ . A bridge-like dorsal saddle spans the sensillary area between the sensillary bases as shown in Fig. 12. The saddle has a concave anterior margin and a biconvex posterior margin forming two prominent lateral lobes or crests, sometimes connected. The sensillary area is narrowed posteriorly into a single apodeme. The convex eye lobes are located postero-lateral to the sensillary bases. Diameter of eyes from 0.2 to 1.0 times the distance between the lateral margins of the sensillary bases.

*Setae*.—Body setae heavily branched, bright red in color. Length of longest lateral humeral setae from 0.4 to 0.8 times length of longest posterior body setae which measure 36 to 76  $\mu$  in the short non-

attenuated type, to 138  $\mu$  in the attenuated type. The apices of the setae are not expanded.

*Genitalia*.—A pair of kidney-shaped genital plates is located medially on the ventral surface of the body posterior to coxae IV. Three elliptical or rounded genital suckers are found on each plate. The males have a genital papilla on each genital plate, each papilla bearing four large fan-like flattened genital setae with the posterior borders heavily fringed as shown in Fig. 14. The penis is large and oval, somewhat egg-shaped, bearing four pairs of short simple penile setae. The females do not have genital papillae on the genital plates, but have in their place a row of three or more nude genital setae as shown in Fig. 15. A pair of small genital rings (sacculi) is located between the genital plates. An oval anus is located posterior to the genital area.

This group of species was first referred to by Ewing (1937) as the *irritans* group of the genus *Trombicula*. The group was composed of larvae having the palpal claw with two prongs and having plumose sensillae. The generic name *Eutrombicula* was proposed for this group by Ewing (1938) and was described as follows: "Chelicerae each with a single dorsal tooth. Palpal claws bifurcate. Eyes present. Dorsal plate with posterolateral corners, without anterior median process, without crista. Median seta of dorsal plate present, barbed; antero-lateral setae with barbs; submedian setae absent; total number of setae on dorsal plate (exclusive of pseudostigmatic organs) five, all marginal. Pseudostigmatic organs setiform or flagelliform, with or without barbs. Dorsal abdominal setae usually less than 30, barbed, arranged in more or less irregular transverse rows. Legs and tarsal claws typical for the subfamily *Trombiculinae*." Ewing designated the type species as *Microthrombidium alfreddugèsi* Oudemans and included 19 species in the genus.

*Eutrombicula* was revised by Ewing (1943) when the genus *Acariscus* was separated as follows: "Dorsal abdominal setae (counting the posterior marginal pair) 22, and arranged, previous to engorgement, as follows: 2-6-6-4-2-2; ventral body setae (counting the 4 sternals, but not counting the 2 posterior marginals) 14, arranged as follows: 2-2-6-2-2." The genus was again redefined, (Ewing 1946b), and the above descriptions combined. The dorsal setal number and arrangement was emphasized.

The genus *Acariscus* was described to include species with more than 22 dorsal abdominal setae and more than 14 ventral setae. The type species was *Trombicula flui* Van Thiel, and 10 species were included in the genus. Womersley (1944) and Womersley and Kohls (1947) did not accept *Acariscus*. Wharton (1945b) described two new species of *Acariscus* but indicated that the genus was not well defined from *Eutrombicula*. Michener (1946a) considered *Acariscus* a synonym, and pointed out the discovery of a new species in Panama, *Trombicula (Megatrombicula) attenuata* Michener (1946b) with 24 dorsal setae which was said to bridge the gap between *Eutrombicula* with 22 setae, and *Acariscus* with 26 or more setae. This species cannot be considered, however, since it belongs in an entirely different group (*Mega-*



*trombicula*). Ewing (1946a and 1946b) reaffirmed *Acariscus* and Michener (1946c) refuted it.

*Acariscus* is here considered a synonym of the subgenus *Eutrombicula* since *Acariscus masoni* larvae were reared by Jenkins (1949) to adults of the previously described *Trombicula* (*Eutrombicula*) *splendens*. Furthermore these larvae sometimes have 24 dorsal setae, appearing to intergrade with *T. alfreddugèsi* in this character, so that no distinctive differences remain to validate *Acariscus*.

*Trombiculoides* was founded as a new genus by Jacot in 1938 on adults which he considered the same as *Trombidium scabrum* Say 1821. In 1946, Ewing considered *Trombiculoides* a synonym of *Sericothrombium* Berlese. Wharton (1948) re-examined Jacot's types and found them closely related to *T. alfreddugèsi*. On the basis of measurements of the types made by Wharton, and furnished to the present author, these adults are typical *T. splendens*. *Trombiculoides* Jacot, 1938, is considered a genus of doubtful status. Wharton (1948) has presented this case to the International Commission on Zoological Nomenclature for decision under Opinion 168.

In *Trombicula sensu lato* of authors for larvae, there is a complete intergradation in the reduction of one of the two small exterior prongs of the palpal claw to only one, as stated by Michener (1946a, c). It is proposed that species previously placed in *Eutrombicula* and *Acariscus*, with two prongs on the palpal claw, the outer of which is smaller, be referred to *Trombicula sensu lato*.

Several series of morphological changes of an orthogenetic type are observed in the members of this subgenus. There appears to be a reduction series in the number and branching of the dorsal and ventral setae in the larvae, from *T. multisetosa* to *T. alfreddugèsi*, as shown in Table I. Of the species with 22 dorsal setae, there is a reduction in the branching of palpal setae from *T. tinami* with all setae four- to six-branched to species with the palpal genual and ventral tibial setae nude. There is also a reduction in the number of long nude setae on tibia and tarsus III.

Five of the seven species and subspecies recognized in the American hemisphere have been observed or recorded to attach to human beings and to cause an inflammatory reaction. In addition to these *Eutrombicula* species, the following have been recorded to attack human beings in the American hemisphere. *Euschöngastia nuñezi* (Hoffmann) in Mexico, *E. guyanensis* (Floch & Abonnenc) and *Trombicula canis* Floch & Abonnenc, in French Guiana, and *T. landazuri* Boshell & Kerr in Colombia.

The common names given to the mites affecting man are quite different in the various countries, and the author has heard most of the following names (among others) used for the larvae of *Eutrombicula*: United States—"chiggers" (northern states), "red bugs" (southern states); Mexico—"tlalzahuatl," "aradores," (Yucatan) "coloradillo"; Guatemala—"aradores"; Honduras—"coloradilla," "pobladores," "ciron"; Costa Rica—"coloradilla"; Panama—"bicho colorado," "coloradilla," "coloradita," "cuscusa"; Cuba—"colorado," "bicho colorado"; Martinique—"bete rouge"; Barbados—"potato louse"; Trinidad—"grass louse"; Colombia—"yaya," "cuitiva," "niabi"; Venezu-

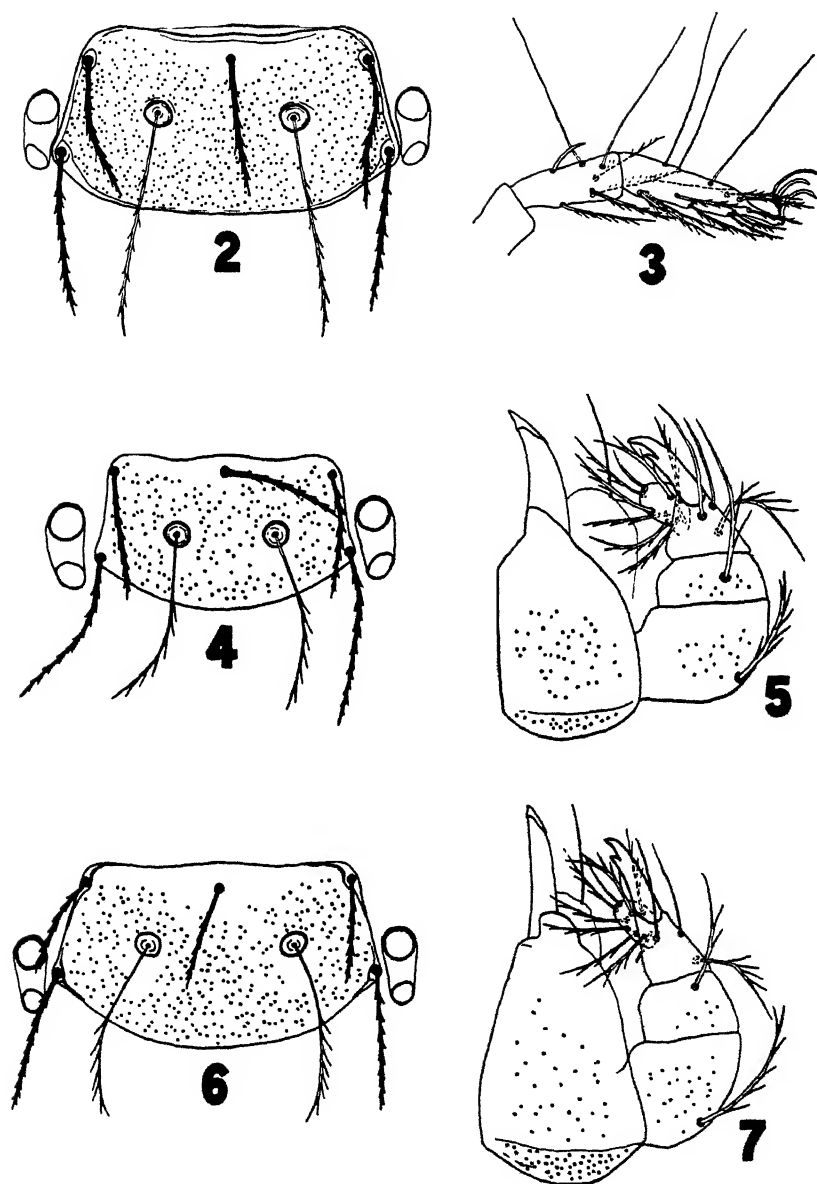


FIG. 2. Scutum of *Trombicula multisetosa* larva. 3. Tarsus III and tibia III of *T. multisetosa* larva. 4. Scutum of *T. batatas* larva. 5. Dorsal view of right palp of *T. batatas* larva. 6. Scutum of *T. alfreddugèsi* larva. 7. Dorsal view of right palp of *T. alfreddugèsi* larva. (Figures 2 and 7 are all drawn to the same scale.)

ela—"chivacoa," (Rio Orinoco) "coloradilla"; French Guiana—"pou d'agouti"; Dutch Guiana—"pou patate," "pattata"; Brazil—"mouqui" (Para) "mucum"; Ecuador—"garrapatilla"; Peru—"japa," "mucum," "inacua"; Uruguay—"bicho colorado"; Argentina—"bicho colorado."

In the following larval key, the dorsal setae refer to the total number including the two humeral setae, the posterior caudal and posterior marginal setae. The ventral setae include the two pairs of sternal setae between the coxae, the ventral abdominal setae, and the dorsal type setae posterior to the anus on the ventral surface. The posterior caudal and marginal setae shift position dependent upon engorgement so that total number of dorsal and ventral setae may have to be considered. In Table I, the standard measurements of the scutum and length of dorsal setae are abbreviations as defined by Wharton (1945a) and Brennan (1947).

TABLE I  
LARVAL CHARACTERISTICS AND MEASUREMENTS

	<i>multi- setosa</i>	<i>batatas</i>	<i>splen- dens</i>	<i>alfred- dugesi</i>	<i>ssp. tropica</i>	<i>tinami</i>	<i>goldii</i>
Number of dorsal setae....	50-54	32-36	26 (24)	22	22	22	22
Number of ventral setae....	42-46	22	16	14	14	16	16
Prong of pedipalpal claw (from base).....	3/4	3/4	3/4	3/4	3/4	1/2	1/2
Number of branches of palpal seta:							
Coxal.....	6-7	8	6-7	4-7	4-6	4-5	4-5
Femoral.....	4-6	4-6	4-6	4-6	4-5	6-7	4-6
Genual.....	1-2	1-3	0-3	0-3	0	4-5	0
Ventral tibial.....	2-4	2-5	3-4	1-4	0	4-5	0
Number of long nude hairs on tarsus III.....	3	3	1	1	1	1	1
Number of long nude hairs on tibia III.....	2	2	0	0	0	0	0
Standard measurements (ave. in $\mu$ ):							
AW.....	79	64	78	81	79	77	77
PW.....	93	71	91	90	86	92	91
SB.....	39	27	44	43	45	45	42
ASB.....	23	21	22	23	21	29	21
PSB.....	29	25	32	31	31	35	32
AP.....	26	23	27	27	24	38	28
AM.....	38	29	37	33	35	58	44
AL.....	38	31	34	33	35	51	40
PL.....	48	43	48	45	48	63	51
S.....	52	52	51	50	48	56	56
DS.....	44	37	49	42	45	56	49
Number measured.....	(4)	(8)	(10)	(18)	(3)	(2)	(12)
Attach to man.....	yes?	yes	yes	yes	yes	no	yes

#### KEY TO AMERICAN TROMBICULA (EUTROMBICULA) LARVAE

- A. Dorsal setae 32 to 54 in number; tibia III with one short curved nude seta and two long nude whip-like setae; tarsus III with three long nude whip-like setae.  
  B. Dorsal setae 50 to 54, heavily barbed; ventral setae 42 to 46; sensillae with many short appressed branches..... *multisetosa*  
  BB. Dorsal setae 32 to 36, lightly barbed; ventral setae 22; sensillae with 5 to 7 spreading branches..... *batatas*

- AA. Dorsal setae 20 to 26; tibia III with one short curved nude seta; tarsus III with one long nude whip-like seta.  
 B. Total dorsal and ventral setae 42; dorsal setae 26 (rarely 24) arranged 2-6-6-4-4-2-2; ventral setae 16. .... *splendens*  
 BB. Total dorsal and ventral setae 36 or 38; dorsal setae 22 or 20 depending upon engorgement.  
 C. Palpal claw with a small inner prong about half the distance from the base; total setae 38, ventral setae 16 arranged 2-2-6-2-2-2.  
 D. All palpal setae four- to seven-branched; scutal setae relatively long. .... *tinami*  
 DD. Palpal genual and ventral tibial setae nude; genual seta long, about 28  $\mu$  in length. .... *göldii*  
 CC. Palpal claw with a nearly equal sized subapical inner prong, about three-fourths the distance from the base; total setae 36, ventral setae 14, arranged 2-2-6-2-2.  
 D. Palpal ventral tibial setae always branched, palpal genual setae usually branched. .... *alfreddugesi*  
 DD. Palpal ventral tibial and genual setae always nude, genual seta about 20  $\mu$  in length. .... *a. ssp. tropica*

TABLE II

## ADULT CHARACTERISTICS AND MEASUREMENTS

	<i>batatas</i>	<i>splendens</i>	<i>alfred- dugesi</i>	<i>göldii</i>	<i>coarctata</i>
Length, mm. ....	0.7-1.0	0.9-1.4	0.9-1.1	1.3-1.5	1.15
Length tarsus I, $\mu$ . ....	190	167-183	167-217	250-264	180
Width tarsus I, $\mu$ . ....	67-71	76-107	71-107	109-117	75
Ratio length to width, tarsus I. ....	2.67-2.83	2.03-2.83	2.0-2.6	2.3-2.8	2.4
Length tibia I, $\mu$ . ....	131-138	119-155	124-171	167-183	130
Width tibia I, $\mu$ . ....	64-67	74-107	71-107	107-119	80
Ratio tarsus I to tibia I. ....	1.41-1.49	1.35-1.6	1.21-1.47	1.25-1.5	1.63
Length of palpal claw, $\mu$ . ....	32-38	38-48	35-41	43-52	
Ratio of claw to palpal tibia. ....	0.6-0.66	0.52	0.55-0.62	0.53-0.61	
Number of apical setae on tarsus	3-5	9-11	7-8	12-14	
Tibial setae at tarsal base. ....	1	2	2	2	
Length scutum, $\mu$ . ....	120-150	144-195	152-190	190-209	
Width between sensillae, $\mu$ . ....	38-47	57-69	48-50	69-74	
Length of sensillae, $\mu$ . ....	131-143	167-179	155-177	250	
Diameter of eye over distance between sensillae. ....	0.75-1.0	0.3-0.5	0.35-0.5	0.25-0.4	
Length longest humeral setae, $\mu$ . ....	31	31-43	30-48	43	25
Length longest posterior setae, $\mu$ . ....	36-40	48-76	45-69	110-138	70
Ratio humeral to posterior seta. ....	0.7-0.8	0.54-0.7	0.6-0.8	0.4-0.55	0.4
Branches of sensillae. ....	3	3-5	4-6	3	

## KEY TO KNOWN AMERICAN TROMBICULA (EUTROMBICULA) ADULTS

- A. Palpal tarsus with 3 to 5 apical nude setae; eyes relatively large 0.75 to 1.0 times breadth of sensillary bases to lateral margins; scutum short (120-150  $\mu$ ); width between sensillae 38 to 47  $\mu$ ; inner tibial setae at tarsal articulation, one. .... *batatas*  
 AA. Palpal tarsus with 7 to 14 apical nude setae; eyes smaller, no more than 0.5 times breadth of sensillary bases to lateral margin; scutum longer (144-209  $\mu$ ); width between sensillae 48  $\mu$  or more; inner tibial setae at tarsal articulation, usually two.  
 B. Palpal tarsus with 12 to 14 apical nude setae; posterior body setae attenuated and long (110-138  $\mu$ ); tarsus I long (250-264  $\mu$ ); width between sensillae 69 to 74  $\mu$ ; sensillae long 250  $\mu$ . .... *göldii*

BB. Palpal tarsus with 7 to 11 apical nude setae; posterior body setae not attenuated, shorter (36–76  $\mu$ ); tarsus I shorter (167–190  $\mu$ ); width between sensillae 48–69  $\mu$ ; sensillae shorter 131–179  $\mu$ .

C. Palpal tarsus with 7 to 8 apical nude setae; width between sensillae 48–51  $\mu$ .....alfreddugèsi

CC. Palpal tarsus with 9 to 11 apical nude setae; width between sensillae 55–70  $\mu$ .....splendens

### **Trombicula (Eutrombicula) multisetosa (Ewing)**

*Acariscus multisetosa* Ewing, 1943, Proc. Ent. Soc. Wash. 54: 65.

*Larva*.—Palpal claw with inner prong subapical to outer prong. Palpi with genual setae 1–2 branched, ventral tibial setae 2–4 branched. Scutum as shown in Fig. 2. Sensillae with many closely appressed branches. Dorsal setae 50–54, ventral setae 42–46. Two long nude whiplike setae on tibia III, and three such setae on tarsus III as shown in Fig. 3.

*Adult*.—Unknown.

This species is relatively rare and is known at the present time only from the United States in Florida and the Florida Keys. It has not been recorded to attack human beings, but unengorged larvae were collected on the author's legs and were removed before they had an opportunity to attach. Series of these larvae were collected in dry grassy habitats by the author on the Florida Keys, and they compare well with the type specimens in the U. S. National Museum. Larvae have been collected, either free living or attached to hosts, only during the winter months from 30 October to 2 January.

### STANDARD MEASUREMENTS

	AW	PW	SB	ASB	PSB	AP	AM	AL	PL	S	DS
Florida.....	83	95	40	21	28	26	41	38	48	52	48
Florida.....	76	93	38	24	28	28	38	38	48	.....	45
Florida.....	76	91	38	21	31	24	36	35	45	52	41
Florida.....	79	93	40	24	28	28	37	38	52	52	43
Ave.....	79	93	39	23	29	26	38	37	48	52	44

### DISTRIBUTION

Florida: Christmas, Bonita Springs, Tallahassee, Shell Point.

\*Florida Keys: Cudjoe Key.

### HOSTS

U. S. .... \* ? *Homo sapiens* ..... ? Man (not attached)

U. S. .... *Procyon lotor* ..... Raccoon

U. S. .... *Sigmodon hispidus littoralis* ..... Cotton Rat

U. S. .... *Sturnella magna argutula* ..... S. Meadowlark

\* New host or locality data.

### **Trombicula (Eutrombicula) batatas (Linnaeus)**

This species is the first described trombiculid mite. The synonymy and numerous references have been compiled by Fuller (1949). The generic and specific names and combinations together with their

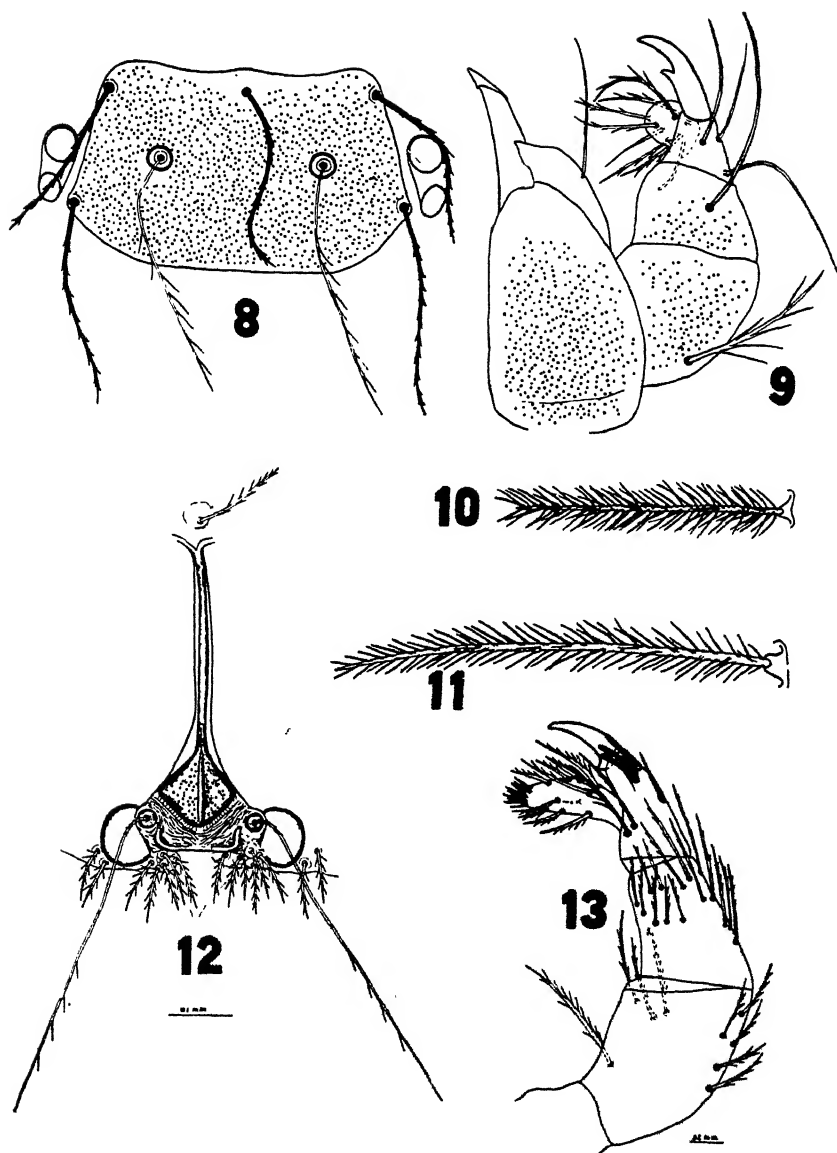


FIG. 8. Scutum of *Trombicula göldii* larva. 9. Dorsal view of right palp of *T. göldii* larva. 10. Posterior body hair of adult *T. splendens*. 11. Posterior body of hair of adult *T. göldii*. 12. Scutum of adult cotype of *T. splendens* showing eyes posterolateral to sensillary bases, sensillae, saddle between sensillary bases, carina and crista. 13. Inner view of palp of adult *T. splendens*. (Figures 8 to 11 are drawn to the same scale as figures 2 to 7, Plate I.)

author and dates are as follows: *Acarus batatas*, Linnaeus (1758); *Gamasus batatus*, Fabricius (1805); ? *Leptus irritans*, Lucas (1847); "*Pattata-luis*," Van Stockum (1904); *Thrombidium batatas*, Oudemans (1905); *Leptus batatus*, Brumpt (1913); *Microthrombidium batatas*, Oudemans (1927); *Trombicula flui*, van Thiel (1930); *Trombicula batatas*, Ewing (1931); *Trombicula hominis*, Ewing (1933); *Otonyssus batatas*, Oudemans (1937); *Eutrombicula hominis*, Ewing (1938); *Eutrombicula flui*, Ewing (1938); *Trombicula pastora*, Boshell and Kerr (1942); *Acariscus flui*, Ewing (1943); *Acariscus hominis*, Ewing (1943); *Eutrombicula batatas*, Michener (1946).

In addition to this list the following new synonymy is added.

*Trombicula brasiliensis* Ewing, 1925, Proc. Ent. Soc., Wash. 27(4): 91-92. Bequaert, 1926, Contr. Harvard Inst. Trop Biol. 4: 152-257. Ewing, 1928, Proc. Ent. Soc. Wash. 30: 77. Stiles and Nolan, 1929, Hyg. Lab. Bull. No. 152, p. 485. André, 1930, Mem. Soc. Zool. 29: 109. Van Thiel, 1930, Parasitology 22: 353. Ewing, 1931, Proc. U. S. Nat. Mus. 80: 7. Ewing, 1933, Proc. U. S. Nat. Mus. 82: 6. Neveu-Lemaire, 1938, Traite d'Ent. etc., p. 492. Torres and Braga, 1939, Bol. Sec. Agr. Indust. 4: 38. Sig. Thor and Willman, 1947, Das Tierreich, 71b: 284-291.

*Eutrombicula brasiliensis* (Ewing) Ewing, 1938, J. Wash. Acad. Sci. 28: 294. Radford, 1942, Parasitology 34: 66.

*Acariscus brasiliensis* (Ewing) Ewing, 1943, Proc. Ent. Soc. Wash. 45: 61-62.

*Larva*.—Palpal claw with inner prong subapical to outer prong. Palpi with genual setae one- to three-branched, ventral tibial setae two- to five-branched. Scutum as shown in Fig. 4. Dorsal setae 32-36, ventral setae 22. Two long nude whip-like setae on tibia III, and three such setae on tarsus III as shown in Fig. 3.

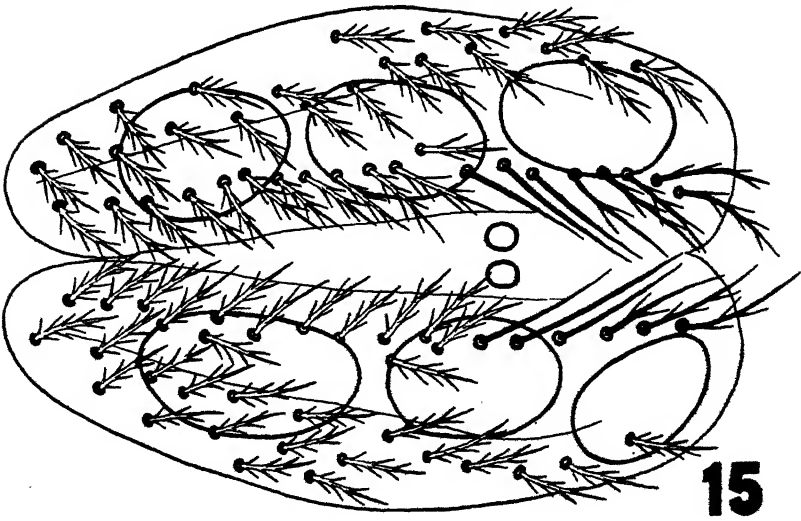
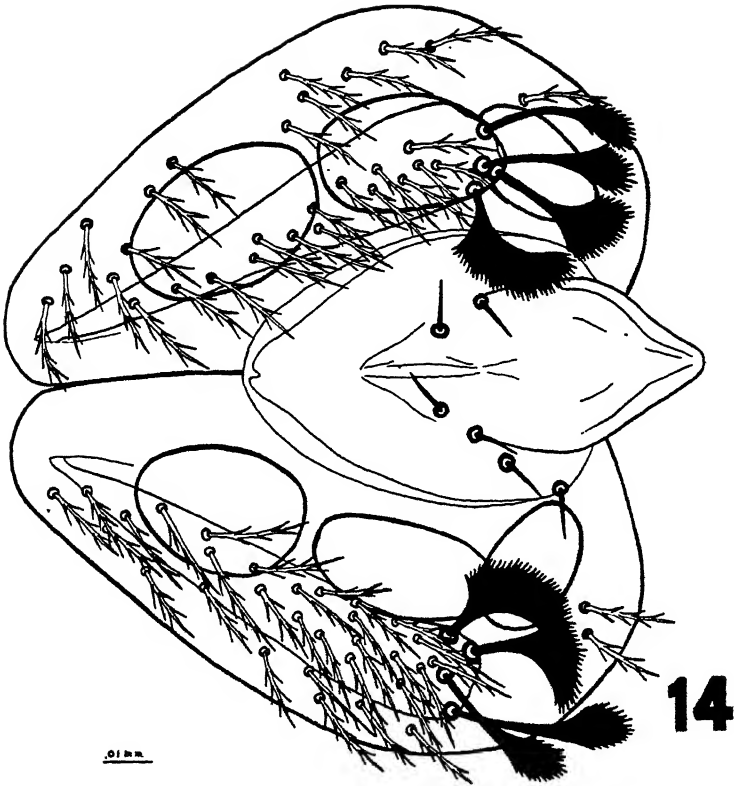
*Adult*.—Length of adults 0.7 to 1.0 mm. Palpal tarsus with three to five nude apical setae. Inner tibial setae at tarsal articulation, one. Width between sensillae 38-47  $\mu$ . Length of sensillae 131-143  $\mu$ . Diameter of eye 0.75 to 1.0 times width of sensillary bases to lateral margins. Length of tarsus I about 190  $\mu$ . Posterior body setae not attenuate, 36-40  $\mu$  in length.

*T. batatas* is one of the most abundant species of chiggers causing trombidiosis of human beings in tropical America. It is an important pest of human beings and of domesticated animals, especially chickens. The known range of the species extends from Brazil to the United States. It is most abundant in open grassy habitats in small inhabited areas in northern South America and Panama.

The type specimens of *T. batatas* are not known to exist. The use of this name has been discussed and the species fully described by Michener (1946a) and Fuller (1949), and rearing methods were presented by Michener (1946a) and Jenkins (1946, 1947). The present author has compared the type specimens of *T. hominis* Ewing, *T. pastora* Boshell & Kerr, *T. brasiliensis* Ewing, and topotypic specimens of *T. flui* van Thiel, and finds them to be indistinguishable. *T. brasiliensis* is considered to be a synonym after examination of the three type specimens from Manaus and other specimens from Carvoeiro,

#### EXPLANATION OF PLATE III

FIG. 14. Ventral view of male genital area of adult *T. splendens*. The four pairs of fan-like genital setae are shown in black. 15: Ventral view of female genital area of adult *T. splendens*.





Brazil, in the U. S. National Museum. All of these are typical *T. batatas* with 34-36 dorsal setae, except that one type specimen has two dorsal setae broken off from their discernible setal pits. All of these specimens have the characteristic palpal and tarsal setae and standard measurements of *T. batatas*.

*T. batatas* is slightly variable over its extensive range and a few minor differences have been noted in the number of branches of the palpal genual and ventral tibial setae, in the sclerotization of the scutum, and setal lengths of tarsi III. These differences were not constant and the standard measurements were not significantly different. With more detailed study of large series of specimens, subspecies might be distinguished.

#### STANDARD MEASUREMENTS

	AW	PW	SB	ASB	PSB	AP	AM	AL	PL	S	DS
Georgia.....	62	75	23	18	20	21	31	35	41	55	35
Georgia.....	73	83	38	23	28	26	26	28	41	52	41
Florida.....	59	59	23	20	23	21	31	28	38	.....	31
Panama.....	59	62	24	21	26	23	28	31	45	52	41
Panama.....	66	73	28	21	30	24	31	35	48	49	38
Ave.....	64	71	27	21	25	23	29	31	43	52	37

#### DISTRIBUTION

##### BRAZIL

Amazonas: Manaos, Carvoeiro, Vista Alegre (?), Boa Esperanca (?), Parima (?).

Para: Para, Ilha de Marejo.

##### DUTCH GUIANA

Paramaribo, Kwatta, Duisberg, Mattonshoop, Leiding, l'Hermitage.

##### FRENCH GUIANA

Cayenne and interior.

##### VENEZUELA

\*Carabobo: Palma Sola.

\*Bolivar: Caicara.

\*Zulia: Rio Chama.

##### COLOMBIA

Bolivar: Landazuri.

Meta: Restrepo.

##### PANAMA

Canal Zone: Juan Mina, Summit.

Panama Province: Panama City, Camaron, Chilibre, Matías Hernández.

Colon Province: Santa Rosa, Gatuncillo.

Agua Buenas.

##### MEXICO

Puebla.

\*Vera Cruz.

\*Chiapas.

##### PUERTO RICO

Guaynabo, Mayaguez.

##### \*JAMAICA

##### UNITED STATES

Florida: Immokalee, \*Brooksville, \*Orlando.

Alabama: Fairhope.

Georgia: Savannah, \*Thomasville.

California: Kern Co., Tulare Co. (Furman & Doetschman, in press).

## HOSTS

D. Guiana, Fr. Guiana, *Ven.,		
Pan., Mexico, U.S., *Brazil.	<i>Homo sapiens</i> .....	Man
Pan., U. S.	<i>Canis familiaris</i> .....	Dog
U. S.	<i>Odocoileus virginianus</i> .....	Deer
Puerto Rico.	<i>Equus caballus</i> .....	Horse
Fr. Guiana.	<i>Equus asinus</i> .....	Donkey
Pan.	<i>Bos bovis</i> .....	Cow
Pan.	<i>Capra hircus</i> .....	Goat
Brazil.	<i>Dasyprocta aguti</i> .....	Agouti
*Jamaica.	* <i>Herpestes griseus</i> .....	Mongoose
Pan.	<i>Rattus</i> sp.....	Rat
Pan.	<i>Sylvilagus gabbi</i> .....	Forest rabbit
U. S.	<i>Sylvilagus floridanus</i> .....	Cottontail rabbit
U. S.	<i>Sigmodon hispidus</i> .....	Cotton rat
U. S.	<i>Didelphis virginiana</i>	
	<i>pigra</i> .....	Opossum
U. S., Pan.	<i>Colinus virginianus</i> .....	Bob white
*U. S., Pan., Col., Puerto Rico,		
D. Guiana.	<i>Gallus gallus</i> .....	Chicken
Col., Puerto Rico.	<i>Numida meleagris</i> .....	Guinea hen
Col., Brazil.	<i>Meleagris gallopavo</i> .....	Turkey
Pan.	<i>Florida caerulea</i> .....	Little blue heron
Pan.	<i>Aramides cajanea</i> .....	Cayenne wood rail
Pan.	<i>Columbigallina talpacoti</i>	
	<i>rufipennis</i> .....	Ground dove
Jamaica.	<i>Columbigallina passerina</i>	
	<i>jamaicensis</i> .....	Ground dove
Pan.	<i>Crotophaga ani</i> .....	Ani
Pan.	<i>Tapera naevia</i> .....	Striped cuckoo
U. S.	<i>Minus p. polyglottos</i> .....	Mocking bird
U. S.	<i>Toxostoma rufum</i> .....	Brown thrasher
U. S.	<i>Sturnella magna</i> .....	Meadowlark
U. S.	<i>Pipilo erythrophthalmus</i> .....	Towhee
Fr. Guiana.	<i>Turdus</i> sp.....	Bird
Pan.	<i>Tyrannus melancholicus</i> .....	Berlepsch's kingbird
Pan.	<i>Myiochanes cinereus</i> .....	Short-legged wood pewee
Pan.	<i>Troglodytes musculus</i> .....	Panama house wren
D. Guiana.		? Lizard

***Trombicula* (*Eutrombicula*) *splendens* Ewing**

*Trombicula splendens* Ewing, 1913, Bull. Amer. Mus. Nat. Hist. 32(5): 113-114. Ewing, 1920, Ann. Ent. Soc. Amer. 13: 381. Ewing, 1926, Ent. News 37: 111-113. Vitzthum, 1929, Zeit. f. Parasit. 2(2): 234. Van Thiel, 1930, Parasitology 22: 353 (refers to *T. splendens* Howard, 1918!). Andre, 1930, Mem. Soc. Zool. France 29: 109. Ewing, 1931, Proc. Nat. Mus. 80: 1-19. Ewing, 1933, Proc. U. S. Nat. Mus. 82: 1-6. Ewing, 1937, Proc. Biol. Soc. Wash. 50: 169. Sig Thor and Willman, 1947, Das Tierreich 71b: 344.

Gen.? sp.? "Irritating chigger" Howard, 1918, Seventeenth Rep. State Entom. Minn. 117: 111-144 (figure of *T. splendens* larva). (New synonymy.)

"American chigger" Ewing, 1921 (Not of Riley, 1873), U. S. Dept. Agr. Bull. 986: 1-19 (figure of *T. splendens* larva). (New synonymy.)

*Trombiculoides scabrum* Jacot, 1938 (nec Say, 1821), Psyche 45: 121-132. New generic name based on incorrect identification. Adults were presumed to be *Trombidium scabrum* Say, 1821.) Ewing, 1946, Proc. Biol. Soc. Wash. 59: 69-72. (Considered to be a synonym of *Sericothrombicum*.) Wharton, 1948, Psyche 55: 139-140. (Identified as closely related to *Eutrombicula alfreddugesi*. (New synonymy.)

*Acariscus masoni* Ewing, 1943, Proc. Ent. Soc. Wash. 45: 60. Farnier, 1946, Proc. Ent. Soc. Wash. 48(2): 32. Farnier and Seaman, 1946, Jour. Parasit. 32: 93. Farnier, 1947, Proc. Biol. Soc. Wash. 60: 29-30. Jenkins, 1946, CWS Quarterly Prog. Rep. 10: 34-38. (New synonymy.)

*Eutrombicula masoni* (Ewing) Jenkins, 1947, Ann. Ent. Soc. Amer. 40: 57. Jenkins, 1948, Amer. Jour. Hygiene 48: 22, 36. Wharton, 1948, Psyche 55: 139. (New synonymy.)  
*Trombicula* (*Eutrombicula*) *splendens* Ewing, Jenkins, 1949, J. Parasit. 35: 201.

*Larva*.—Palpal claw with inner prong subapical to outer prong. Palpi with genual setae unbranched to three- (usually one- to two-) branched, ventral tibial setae three- to four-branched. Scutum as shown in Fig. 1. Dorsal setae 26 (rarely 24), ventral setae 16. Tibia III with no long nude whip-like setae, tarsus III with one such seta.

*Adult*.—Length 0.9–1.4 mm. Palpal tarsus with nine to eleven simple apical setae. Inner tibial setae at tarsal articulation, usually two. Width between sensillae 57–69  $\mu$ . Length of sensillae 167–179  $\mu$ . Diameter of eye 0.3–0.5 times width of sensillary bases at lateral margins. Length of tarsus I from 167–183  $\mu$ . Posterior body setae not attenuate, 48–76  $\mu$  in length.

The larvae of *T. splendens* are the most important cause of human trombidiosis in the southeastern part of the United States, especially in Florida. They are most abundant in swamps, bogs, and moist places along the coastal plain and inland about 150 miles from Texas to Florida and north to Massachusetts. This species is also found through the Great Lakes region and up the Mississippi River valley to Minnesota. Larvae of this species have been used in extensive tests in relation to chigger repellents, miticide impregnation of clothing, and chemical area control of the larvae. The bionomics and behavior are discussed by Jenkins (1948a, b), and a map of the distribution of the species by counties in the United States is presented.

This species was first discovered in the adult stage in 1909 under stones in a tamarack bog in Wisconsin and was named *Trombicula splendens* by Ewing (1913). The larvae were discovered in Minnesota and figures were published by Howard in 1918 and by Ewing in 1921, but they were unidentified and were not correlated with the adults. The larvae were finally described from Florida specimens and named *Acariscus masoni* by Ewing (1943), but the adults were unknown. Topotypic larvae which had been compared with the types of *A. masoni* were reared through several generations by Jenkins (1947). The reared adults were compared with the existing type specimens of *T. splendens* and were found to be the same by Jenkins (1949), and consequently *A. masoni* was dropped as a valid species. The type specimens of *T. splendens* consist of a type adult in poor condition in the U. S. National Museum, and a cotype adult in the American Museum of Natural History which was kindly loaned by Dr. C. D. Michener. These types were remounted in polyvinyl alcohol and the cotype is illustrated in Figs. 11 to 13. In the original description of the adult by Ewing in 1913, the eyes are said to be absent, and in 1920 it is stated by the same author that the sensillae (pseudostigmatic organs) originate between the sensillary bases (pseudostigmata). In the type, cotype, and reared adults, eyes are present and the sensillae originate from the centers of the sensillary bases as shown in Fig. 12.

The larvae are somewhat variable, and as stated previously, a pair of dorsal setae may be absent leaving 24 dorsal setae. In the southern United States, it is not uncommon to find white or slightly pinkish

instead of the usual red larvae. This variation occurs in local populations and is apparently a genetic albino character. This albino type of larvae has also been obtained in rearing colonies. No morphological character has been found to be correlated with it. The larvae are very closely related to *T. wickmanni* (Oud.) of New Guinea and the southwestern Pacific area. *Trombiculoides* Jacot, 1938, is discussed previously under subgenus *Eutrombicula*.

## STANDARD MEASUREMENTS

	AW	PW	SB	ASB	PSB	AP	AM	AL	PL	S	DS
Florida.....	76	86	40	21	35	26	38	20	48	52	47
Florida.....	77	87	41	21	31	28	38	35	45	52	48
Florida.....	76	86	41	21	31	28	38	35	52	52	52
Florida.....	79	97	45	24	28	31	38	35	38	52	52
Florida.....	79	91	41	21	28	24	38	35	48	48	48
Florida.....	76	83	41	21	31	24	38	35	48	52	48
Alabama.....	79	97	47	21	31	28	38	31	57	52	50
Texas.....	79	93	45	24	35	28	38	38	48	48	48
Texas.....	79	95	47	22	35	24	35	35	46	52	48
Texas.....	79	97	47	21	31	28	31	31	45	48	45
Ave.....	78	91	44	22	32	27	37	34	48	51	49

## DISTRIBUTION

## UNITED STATES

Minnesota, Wisconsin, Michigan, Massachusetts, Delaware, Maryland, District of Columbia, Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Texas, \*Tennessee, \*Arkansas. Also reported from Kansas and Nebraska.

## CANADA

\*Ontario: Welland Co.

## HOSTS

The known hosts, Jenkins (1948a) include 42 species of mammals, birds, reptiles, and amphibians. Reptiles, especially snakes and turtles, appear to be the most important natural hosts. Human beings are readily attacked and a severe inflammatory reaction is produced by the larvae.

*Trombicula* (*Eutrombicula*) *alfreddugèsi* (Oudemans)

The synonymy and references to *T. alfreddugèsi* are very extensive and the majority of them have been cited in full by Fuller (1949). The various generic and specific names, authors and dates of the names are as follows: *Leptus irritans*, Riley (1873); *Tetranychus tlalsahuatl*, Murray (1877); *Tetranychus irritans*, Murray (1877); *Trombidium irritans*, Hamilton (1896); *Trombidium tlalsahuatl*, Brumpt (1910); *Microthrombidium alfreddugèsi*, Oudemans (1910); *Microthrombidium tlalsahuatl*, Oudemans (1912); *Trombicula cinnabaris*, Ewing (1921); *Leptus similis*, Hirst (1921); *Trombicula irritans*, Ewing (1925); *Trombicula tlalsahuatl*, Ewing (1923); *Trombicula alfreddugèsi*, Ewing (1938); *Eutrombicula alfreddugèsi*, Ewing (1938); *Leptus rileyi*, Oudemans (1939).

Many emendations of spelling and lapses can also be added to the preceding list. For the validity of the present name and reasons for the above synonymy see Ewing, 1938, Proc. Helm. Soc. Wash. 5: 26-27.

The following new synonymy is presented:

- Trombicula irritans* var. *uruguayensis* Andre, 1930, Ann. Parasit. Hum. and Comp. 8 (3 & 4): 355-361. Vitzthum, 1931, Kükenthal's Handbuch der Zoologie 3 (9) 127. Floch and Abonnenc, 1941, Inst. Past. Guyane et Terr. de l'Inini. Pub. 20: 1.
- Trombicula vanommereni* Schierbeek, 1937, Ann. Parasit. Hum. and Comp. 15 (4): 326-329. Neveu-Lemaire, 1938, Traite d'Entomologie, etc., p. 493. Van Thiel and van Ommeren, 1940, Geneesk. Tijdschr. Ned. Ind. 80 (27): 1639. Van Thiel and van Ommeren, 1941, Acta Leidensia, 15-16: 290. Radford, 1942, Parasitology 34 (1): 60. Not of Floch and Abonnenc, 1941, incorrect determination, see *T. goldii*.
- Eutrombicula vanommereni* (Schierbeek) Michener, 1946, Ann. Ent. Soc. Amer. 39: 413.
- Trombicula butantanensis* Da Fonseca, 1932, Mem. Inst. Butantan 7: 147-155. Neveu-Lemaire, 1938, Traite d'Entomologie, p. 493. Torres and Braga, 1939, Bol. Sec. Agr. Indust. Com. 4: 38.
- Eutrombicula butantanensis* (Da Fonseca) Ewing, 1938, Jour. Wash. Acad. Sci. 28: 294. Radford, 1942, Parasitology 34: 66.
- Acariscus butantanensis* (Da Fonseca) Ewing, 1943, Proc. Ent. Soc. Wash. 45: 63.

*Larva*.—Palpal claw with inner prong subapical to outer prong. Palpi with genual setae unbranched to three- (usually one- to two-) branched, ventral tibial setae one- to four-branched. Scutum of *alfreddugèsi* type as shown in Fig. 6. Dorsal setae 22, ventral setae 14. Tibia III with no long nude whip-like setae, tarsus III with one such seta.

*Adult*.—Length 0.9-1.1 mm. Palpal tarsus with seven to eight nude apical setae. Inner tibial setae at tarsal articulation two (rarely one or three). Width between sensillae 48 to 50  $\mu$ . Length of sensillae 155-177  $\mu$ . Diameter of eye 0.35-0.5 times width of sensillary bases to lateral margins. Length of tarsus I 167-217  $\mu$ . Posterior body setae not attenuated, 45-69  $\mu$  in length.

*T. alfreddugèsi* is the most widespread species and the most important cause of human trombidiosis in the American hemisphere. It is locally common in a wide range of habitats from New York and Ontario, Canada to North Dakota and California south through Central America and the West Indies and South America to Brazil, Uruguay, and probably Argentina. The larvae are important pests of human beings and cause a severe inflammatory reaction. This species is the one commonly encountered in blackberry patches and in the usual picnic and recreation areas in North America.

The larvae are quite variable and a number of species and varieties have been described on the basis of minor variations. After collection of large series in the United States, Venezuela and Panama, and examination of all available material from other countries, (about 3000 specimens), the author regards *T. alfreddugèsi* as a species with a wide latitude of natural variation which can be divided into the type form and one recognizable subspecies. A detailed study of the variation of the branching of the palpal setae and sensillae, and of the standard measurements was made to determine the status of closely related species. These data are tabulated in Tables III and IV. The standard measurements of a topotype of *T. vanommereni* were made by the author, and the types of this species and topotypes of *T. alfreddugèsi* were measured in European museums by Fuller (1949). *T. vanommereni* van Thiel was originally described by comparison with the

distantly related *T. batatas*, and it was not compared with *T. alfreddugèsi* from which it differs only in having the palpal genual seta nude. Michener (1946c) regarded this species as distinct and stated that the larvae were constantly different from closely related species. The present author collected specimens from Panama and found the palpal genual setae to be nude, or with one or two branches. In Venezuela, large series of specimens from single collections averaged 60 per cent with the palpal genual and ventral tibial setae nude (*T. a.* subsp. *tropica*), 40 per cent with the tibial setae branched, of which 25 per cent had the genual seta nude, and the remainder with the genual seta with one or more branches. Larval specimens identified as *T. alfreddugèsi* from the United States in Florida, California, Ohio, Illinois, Kansas

TABLE III  
VARIATION IN BRANCHING OF PALPAL SETAE AND SENSILLAE OF  
*T. alfreddugèsi* AND SUBSP. *tropica*

	Coxal	Femoral	Genual	Ventral tibial	Sensillae
Virginia.....	6	4-6	2-3	3-4	5-8
Kansas.....	6	2	0	1	....
Ohio.....	4-5	4-6	0-2	3-4	5
Nebraska.....	5-6	5-6	0-1	3-4	5
Florida.....	5-7	4-6	0-1	0-4	6
Texas.....	6	5-6	1-2	3-4	5
California.....	6	5	0-1	2-3	5-8
Mexico.....	6	5-6	0-4	2-4	5
Panama.....	5	5	0-2	0-3	5-6
Venezuela.....	5-7	6	0-2	0-6	6
Uruguay.....	6	6	2	4	....
Brazil.....	5-7	5	0	4	5

and North Dakota had the palpal genual seta nude or branched in the same collection or locality. Perhaps the most conclusive evidence of the normal variation found in *T. alfreddugèsi* is the study of topotypes of this species from Mexico by Fuller (1949) who states, "the setae on palpal segment III (genual) are variable on two sides of a single specimen, being nude, or bearing a single short cilia proximal to the midpoint. This applies to the topotypic material as well as to specimens from the United States." The present author has also observed this in specimens from several countries, and this would eliminate the only known difference between larvae of *vanommereni* and *alfreddugèsi*. The specimens identified as *T. vanommereni* by Floch and Abonnenc (1941) are *T. göldii*. There are no known distribution or host records of *vanommereni* which show any differences from *T. alfreddugèsi*. The adults of *T. vanommereni* reared by Michener (1946c) were compared with adults of *T. alfreddugèsi* and were found to be almost indistinguishable. An adult specimen of *vanommereni* had only one inner palpal tibial seta at the tarsal articulation, while *T. alfreddugèsi* usually has two setae.

*Trombicula irritans* var. *uruguayensis* André (1930) was described by a detailed comparison with the published description of *Microthrombidium italzahuatl* Oudemans (1912). The description of the variety appears to be the same as *T. alfreddugèsi* except that the palpal setae are slightly more branched in the variety *uruguayensis*. Fuller (1949) examined cotype specimens of André and considers them to be *T. alfreddugèsi* but perhaps representing a composite. The palpal setae of the cotypes were not more branched. The present author examined topotypic specimens from Uruguay and identified them as typical *T. alfreddugèsi*.

*Trombicula butantanensis* Da Fonseca, 1932, was originally described as having 28 dorsal setae arranged 2:8:8:2:4:2:2 and with 16 ventral setae. At the request of the present author, Dr. Flavio Da

TABLE IV

STANDARD MEASUREMENTS OF *T. alfreddugèsi* AND SUBSP. *tropica* (IN MICRONS)

Location	AW	PW	SB	ASB	PSB	AP	AM	AL	PL	S	DS
Virginia.....	93	100	45	21	31	24	39	38	55	59	45
Ohio.....	90	91	45	21	31	25	.....	31	48	52	39
Missouri.....	74	87	42	24	28	28	28	29	42	42	35
Texas.....	69	83	35	21	26	26	35	31	41	48	41
Texas.....	69	85	41	21	31	24	28	31	41	48	41
Texas.....	71	86	39	21	26	26	24	31	41	48	41
Florida.....	75	89	43	24	28	27	30	28	41	47	35
Florida.....	77	90	43	26	35	28	28	28	39	48	38
Florida.....	81	86	43	26	35	28	28	28	41	48	35
Florida Keys....	76	86	39	25	35	26	28	29	45	48	38
Mexico.....	76	84	39	28	28	29	43	42	59	.....	55
Panama.....	77	88	43	20	30	26	31	31	41	48	38
Panama.....	79	86	45	20	31	27	31	31	41	48	41
Panama.....	90	100	45	24	35	31	41	38	49	59	49
Panama.....	90	100	45	24	35	28	41	41	52	59	55
Dutch Guiana....	80	95	44	24	31	27	31	35	42	49	35
Venezuela.....	79	86	45	21	31	24	35	35	48	48	45
Venezuela.....	85	95	45	24	31	24	35	41	45	.....	45
Ave.....	81	90	43	23	31	27	33	33	45	50	42

Fonseca reexamined the holotype and found 20 dorsal setae and 16 ventral setae. He then very kindly loaned the holotype of this species for further study. The single larva is mounted on slide 23 numbered 00028 and labeled "Holotypo-capt. sobre J. B. Arantes, 12.II.32." The larva was collected from the arm of a man and is fully engorged, with the typical 20 dorsal and 16 ventral setae of engorged larvae. It agrees in every observed detail with *T. alfreddugèsi*, having nude genual and branched ventral tibial palpi as in the named variation *T. vanommereni*. The standard measurements closely approximate the average of *T. alfreddugèsi*. The holotype has been returned to the Instituto Butantan, Sao Paulo, Brazil.

## DISTRIBUTION

UNITED STATES: From New York to North Dakota and south to Florida and Texas, also in Arizona and California. For detailed distribution see Jenkins (1948a).

## \*CANADA

Ontario: Welland Co.

## MEXICO

Puebla: Matamoras, Acatlan.

Yucatan: Chichen Itza.

Temascaltepec.

## PANAMA

Colon Province: Santa Rosa, Agua Clara, Gatuncillo, Rio Limon.

Panama Province: Rio Limon, Matías Hernández, Las Guacas.

Canal Zone: Gatun Lake, Juan Mina.

Darian Province: El Real.

Parito, Aguas Buenas.

## BRAZIL

Sao Paulo: Butantan.

Matto Grosso: Correntes.

## VENEZUELA

\*Bolívar: Puruey, Caicara.

\*Carabobo: Palma Sola.

Zulia: Rio Chama.

## DUTCH GUIANA

Paramaribo, Duisburg.

## \*PERU

Lima.

## URUGUAY

Montevideo.

## WEST INDIES

Bahama Islands.

Cuba: Cabo Cruz.

Haiti: San Michel.

\*Trinidad: Tumpuna.

## HOSTS

The natural hosts for this species are mammals, birds, reptiles, and amphibians. A list of 71 known hosts in the United States was presented by Jenkins (1948a). Additional host records from Texas by Melvin et al. (1943) and Brennan (1945) are compiled with other host records from various countries of the American hemisphere.

U. S., Mex., \*Ven., D.

Guiana, Uruguay,

Brazil..... *Homo sapiens*..... Man

Pan..... *Canis familiaris*..... Dog

Pan..... *Pecari angulatus*..... Peccary

Pan..... *Odocoileus chiriquensis*..... White tailed deer

U. S., Pan..... *Capra hircus*..... Goat

Pan..... *Nasua narica panamensis*..... Coati

Pan..... *Hydrochoerus isthmius*..... Capybara

Pan..... *Dasyprocta punctata*..... Spotted agouti

Uruguay..... *Cavia aperea*..... Guinea pig

Pan..... *Sylvilagus gabbi*..... Forest rabbit

Mex..... *Citellus variegatus rupestris*..... Mexican rock squirrel

\*Can..... *Microtus p. pennsylvanicus*..... Field mouse.

U. S..... *Dasybus novemcinctus texanus*..... Armadillo

Pan..... *Butorides v. virescens*..... Green heron

Uruguay..... *Nothura maculosa*..... Spotted nothura

Pan., D. Guiana..... *Gallus gallus*..... Chicken

Cuba..... *Mniotilta varia*..... Black and white warbler

Pan..... *Arremonops conirostris*..... Lafresnay's sparrow

U. S..... *Crotalus atrox*..... Diamond-back  
rattlesnake



Pan.....	<i>Drymarchon corais melanurus</i> .....	Gopher snake
Pan.....	<i>Spilotes pullatus</i> .....	Rat snake
Brazil.....	<i>Ophis merremii</i> .....	Boipeva snake
U. S.....	<i>Thamnophis sauritus</i>	
	<i>proximus</i> .....	Western ribbon snake
U. S.....	<i>Thamnophis marcianus</i> .....	Marcy's garter snake
U. S.....	<i>Thamnophis eques</i> .....	White-bellied garter snake
U. S.....	<i>Masticophis flagellum</i>	
	<i>testaceus</i> .....	Coach whip snake
U. S.....	<i>Masticophis taeniatus girardi</i> .....	Striped racer
U. S.....	<i>Elaphe obsoleta confinnis</i> .....	Chicken snake
Uruguay.....	<i>Teius teyon</i> .....	Lizard
U. S.....	<i>Cnemidophorus gularis</i> .....	Race runner
U. S.....	<i>Sceloporus olivaceus</i> .....	Large-scaled swift
U. S.....	<i>Sceloporus undulatus fasciatus</i> .....	Small-scaled swift
U. S.....	<i>Phrynosoma cornuta</i> .....	Horned toad
Mex.....	<i>Ameiva undulata undulata</i> .....	Lizard
Pan.....	<i>Ameiva praesignis</i> .....	Lizard
Ven.....	<i>Anadia bitaeniata</i> .....	Lizard
Bahamas, Haiti, D. Guiana.....		Lizard

### ***Trombicula (Eutrombicula) alfreddugèsi* subspecies *tropica* (Ewing)**

*Trombicula irritans* var. *tropica* Ewing, 1925, Amer. Jour. Trop. Med. 5: 258. Sambon, 1928, Ann. Trop. Med. and Parasit. 22: 77. Ewing, 1929, Proc. Ent. Soc. Wash. 31: 10. Andre, 1930, Mem. Soc. Zool. France 29: 109. Van Thiel, 1930, Parasitology 22: 353.

*Trombicula tropica* (Ewing) Ewing, 1931, Proc. U. S. Nat. Mus. 80(8): 10.

*Eutrombicula tropica* (Ewing) Ewing, 1938, Jour. Wash. Acad. Sci. 28: 294. Radford, 1942, Parasitol. 34: 66. Michener, 1946, Ann. Ent. Soc. Amer. 39: 414. *Trombicula lacertillae* Boshell and Kerr, 1942, Rev. Acad. Colomb. Cien. Exact., etc., 5: 12. (New synonymy.)

*Trombicula (Eutrombicula) ilalsahuata* var. *tropica* (Ewing) Sig Thor & Willman, 1947, Das Tierreich 71b: 276.

*Larva*.—Similar to *T. alfreddugèsi* except that the palpal genual and ventral tibial setae are always nude.

*Adult*.—Unknown.

This subspecies appears to have the same habitat and host requirements as *T. alfreddugèsi*, and also causes human trombidiosis. It was originally described as a variety and then changed to a full species. In the original description of var. *tropica*, the "rostral collar" was described as being larger and more conspicuous than in *alfreddugèsi*, and the palpi similar but the femoral palpal setae were said to typically have one long barb near the tip and slightly below it a small short barb, barbs varying from one to four.

Examination of the type specimens in the U. S. National Museum, and series of specimens collected by the author from Venezuela, Panama and Florida show these characters to be without taxonomic significance. The type specimens of *tropica* are distinctive in having the palpal genual and ventral tibial setae without branches. After examining large series of specimens from New England to Nebraska and south to Uruguay, *T. alfreddugèsi* was found to be most abundant in the north and south temperate regions, while typical *tropica* specimens were found only in tropical regions from Florida and California south to Venezuela and Colombia. The *tropica* variation is considered to be a subspecies with a somewhat doubtful status, since it has not been observed to be geographically segregated from *T. alfreddugèsi*. The

subspecies has been collected in grassy areas especially near streams and swamps.

Paratypes of *Trombicula lacertillae* Boshell and Kerr from Colombia deposited in the U. S. National Museum, are indistinguishable from the types of subspecies *tropica*, according to the writer's observations. The standard measurements of *tropica*, *lacertillae* and *T. alfreddugèsi* are not significantly different:

## DISTRIBUTION

## VENEZUELA

Zulia: Chama River.

\*Bolívar: Puruey, Caicara.

\*Carabobo: Palma Sola.

## COLOMBIA

Santander: Cimitarra, Mun. de Bolívar

Meta: Restrepo, Villavicencio.

## PANAMA

\*Canal Zone.

## PUERTO RICO

## UNITED STATES

Florida.

\*California.

## HOSTS

*Ven., *Florida.....	<i>Homo sapiens</i> .....	Man
Puerto Rico.....	<i>Equus caballus</i> .....	Horse
Ven.....	<i>Anadia bitaeniata</i> .....	Lizard
*Pan.....	.....	Lizard
Colombia.....	.....	Blue-headed lizard

***Trombicula (Eutrombicula) tinami* (Oudemans)**

*Microthrombium tinami* Oudemans, 1910, Ent. Ber. 3. 3(54): 84. Oudemans, 1912, Zool. Jb., Suppl. 14 (1): 24-26, 189, 201.

*Trombicula tinami* (Oudemans) Methlagl, 1928, Dentschr. Akad. Wiss. Wien, 101: 216, 223, 224. Ewing, 1931, Proc. U. S. Nat. Mus. 80 (8): 10. Sig Thor & Willman, 1947, Das Tierreich 71b: 279.

*Eutrombicula tinami* (Oudemans) Ewing, 1938, J. Wash. Acad. Sci., 28: 294. Radford, 1942, Parasitology 34: 67.

*Otonyssus tinami* (Oudemans) Buitendijk, 1944, Zool. Meded. 24: 338.

*Larva*.—Palpal claw with inner prong about one-half as long and located medially to outer prong. Palpi with genual setae four- to five-branched, ventral tibial setae four- to five-branched. Scutum of *goldii* type as shown in Fig. 8. Dorsal setae 22, ventral setae 16. Tibia III with no long nude whip-like setae, tarsus III with one such seta.

*Adult*.—Unknown.

*T. tinami* appears to be closely related to *T. goldii*. It has not been reported to attack human beings and nothing is known of its bionomics. Fuller (1949), examined the type material in the Oudemans and Trouessart collections, and the present author borrowed the type. The original description and figures were verified; however, the branching of the palpal genual setae was somewhat less.

## DISTRIBUTION

BRAZIL (locality not specified).

## HOSTS

Brazil.....	<i>Crypturellus noctivagus</i> .....	Red-footed tinamou
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**Trombicula (Eutrombicula) göldii** (Oudemans)

- Microthrombidium göldii* Oudemans, 1910, Ent. Ber. 3(54): 84. Oudemans, 1912, Zool. Jb. Suppl. 14 (1): 13-15, 188, 201.
- Trombicula göldii* (Oudemans) Bequaert, 1926, Med. Rept. Hamilton Rice Exped., Chap. 14: p. 178. Methlagl, 1928, Denkschr. Akad. Wiss. Wien, 101, pp. 216, 223, 224. André, 1930, Mem. Soc. Zool. Fr. 29(2): 109. Ewing, 1931, Proc. U. S. Nat. Mus. 80: 7. Boshell and Kerr, 1942, Rev. Acad. Colomb. Ciencias 5: 112.
- Eutrombicula göldii* (Oudemans) Ewing, 1938, J. Wash. Acad. Sci. 28: 294. Radford, 1942, Parasitology 34: 66. Fairchild, 1943, Amer. J. Trop. Med. 23: 587. Ewing, 1944, J. Parasit. 30: 344. Michener, 1946, Ann. Ent. Soc. Amer. 39: pp. 101 and 414.
- Olonyssus göldii* (Oudemans) Buitendijk, 1945, Zool. Meded. 24: 338.
- Microthrombidium helleri* Oudemans, 1911, Ent. Ber. 3(57): 120. Oudemans, 1912, Zool. Jb. Suppl. 14(1): 15-18, 188, 201. Oudemans, 1927, Tijdschr. v. Ent. 70: 72. Van Thiel, 1930, Geneesk. Tijdschr. Ned. Ind. 70: 48. (New synonymy.)
- Trombicula helleri* (Oudemans) Methlagl, 1928, Denkschr. Akad. Wiss. Wien 101: 216, 223, 224. Van Thiel, 1930, Parasitology 22(3): 346. Ewing, 1931, Proc. U. S. Nat. Mus. 80: 8. Schierbeek, 1937, Ann. Parasit. Hum. Comp. 15: 328. Van Thiel and van Ommeren, 1940, Geneesk. Tijdschr. Ned. Ind. 80(27): 1638. (New synonymy.)
- Eutrombicula helleri* (Oudemans) Ewing, 1938, J. Wash. Acad. Sci. 28(6): 294. Radford, 1942, Parasitology 34(1): 66. Michener, 1946, Ann. Ent. Soc. Amer. 39: 411. (New synonymy.)
- Trombicula vanommereni* Schierbeek. Floch and Abonnenc, 1941, (not of Schierbeek, 1937), Inst. Pasteur Guyane Pub. 20: 1-22, Pub. 40: 1-5, Pub. 64: 1-4. (New synonymy.)
- Eutrombicula defecta* Ewing, 1946, J. Parasit. 32: 439. (New synonymy.)

**Larva.**—Palpal claw with inner prong about one-half as long and located medially to outer prong. Palpi with genual setae nude (rarely one-branched), ventral tibial setae nude as shown in Fig. 9. Scutum shown in Fig. 8. Dorsal setae 22, ventral setae 16. Tibia III with no long nude whip-like setae, tarsus III with one such seta.

**Adult.**—Length 1.3-1.5 mm. Palpal tarsus with 12 to 14 nude apical setae. Inner tibial setae at tarsal articulation, two. Width between sensillae 69-74  $\mu$ . Length of sensillae about 250  $\mu$ . Diameter of eye 0.25-0.4 times width of sensillary area. Length of tarsus I from 250 to 264  $\mu$ . Posterior body setae long and attenuated 110 to 138  $\mu$ .

In tropical America, *T. göldii* is an important pest, and a cause of human trombidiosis. In Venezuela and Panama engorged larvae were removed from the author's skin, where they had produced the typical inflammatory reaction. Human beings have been reported to be attacked in Dutch Guiana, French Guiana, and Colombia. The larvae are found most commonly in the tropical forest, especially second growth jungle areas, where they may be locally abundant.

The larval types of *T. göldii* and *T. helleri* were well described and illustrated by Oudemans (1912). Careful study of the descriptions and illustrations reveal no specific differences between the two forms. Fuller (1949) has studied the types of *T. göldii* in the Trouessart collection and confirmed the original description. Unfortunately it was not possible for him to compare them with the type of *T. helleri* which was originally placed in the Hamburg Museum. Specimens of *T. helleri* larvae and an adult collected by Michener (1946c) and larvae collected by the author in Panama were compared with larvae and adults of *T. göldii* collected by Boshell and Kerr (1942) from Colombia

and they were found to be indistinguishable. From the illustrations and descriptions of larval specimens from French Guiana identified as *T. vanommereni* by Floch and Abonnenc, it is apparent that they are *T. göldii*. This was confirmed by Fuller and the author on specimens from French Guiana sent by Dr. Abonnenc. The two cotype larval specimens of *Eutrombicula defecta* Ewing were studied by the author in the U. S. National Museum, and were found to be faded poorly mounted specimens, one of *T. göldii*, and one *T. alfreddugesi*. In the original description by Ewing, the palpal femoral setae and the sensillae are said to be nude. Under oil immersion it is observed that these setae are normally branched, and that the described small inner prong of the palpal claw is due to the position in which the palpi are mounted. The present author has designated U. S. N. M. type 1429 as lectotype, and *Eutrombicula defecta* Ewing is thus considered to be a synonym of *T. göldii*. The standard measurements of specimens of *T. göldii* from Venezuela, Colombia and Panama are presented in Table V.

TABLE V  
STANDARD MEASUREMENTS OF *T. göldii*

	AW	PW	SB	ASB	PSB	AP	AM	AL	PL	S	DS
Venezuela.....	79	97	48	21	35	31	.....	45	63	.....	63
Panama.....	81	93	45	21	35	28	41	40	48	59	45
Panama.....	76	86	39	21	.....	26	41	37	52	55	43
Panama.....	79	93	43	21	31	30	41	38	48	55	45
Panama.....	79	90	43	21	31	26	41	38	45	57	45
Panama.....	79	90	43	21	31	28	45	38	48	55	45
Panama.....	79	90	41	23	29	28	41	38	48	52	45
Panama.....	76	88	39	21	28	28	41	36	48	.....	45
Colombia.....	79	97	48	24	39	35	59	52	59	55	59
Colombia.....	73	97	41	21	35	31	55	48	59	.....	55
Colombia.....	62	76	30	18	24	18	41	31	45	.....	45
Colombia.....	76	90	39	21	35	27	41	38	48	59	48
Ave.....	77	91	42	21	32	28	44	40	51	56	49

#### DISTRIBUTION

##### VENEZUELA

\*Carabobo: Palma Sola.

##### BRAZIL

Para: Para.

##### DUTCH GUIANA

Paramaribo.

##### FRENCH GUIANA

Cayenne.

River Compté.

##### COLOMBIA

Meta: Restrepo, Villavicencio.

Santander: Bolivar.

Boyaca: Muzo.

##### PANAMA

Panama Province: Panama City, Point Viqué.

Colon Province: Santa Rosa, Gatuncillo.

Herrera Province: Parita.

Canal Zone: Juan Mina, Barro Colorado Island, Irwin Island.

## HOSTS

Pan., Col., *Ven., D.		
Guiana, Fr. Guiana	<i>Homo sapiens</i>	Man
Fr. Guiana	<i>Canis familiaris</i>	Dog
Col.	<i>Icticyon venaticus</i>	
Col.	<i>Cerdocyon</i>	
Pan.	<i>Felis pardalis</i>	Ocelot
Pan.	<i>Tapirella bairdii</i>	Tapir
Pan.	<i>Mazama sartorii reperticia</i>	Deer
Col., Brazil, Fr. Guiana	<i>Dasyprocta aguti</i>	Agouti
Col.	<i>Dasyprocta variegata</i>	Agouti
Pan.	<i>Dasyprocta punctata</i>	Agouti
Col.	<i>Cuniculus paca</i>	Paca
Pan.	<i>Rattus</i> sp.	Rat
Pan.	<i>Proechimys</i> sp.	Spiny rat
Col.	<i>Proechimys chrysaеolus</i>	Spiny rat
Pan.	<i>Sylvilagus gabbi</i>	Forest rabbit
Col.	<i>Nasua dorsalis</i>	Coati
Pan.	<i>Dasyus novemcinctus fenestratus</i>	Armadillo
Pan.	<i>Marmosa mexicana isthmica</i>	Opossum
Col., Pan.	<i>Didelphis marsupialis</i>	Opossum
Col.	<i>Philander laniger</i>	Opossum
Col.	<i>Metachirus nudicaudatus colombianus</i>	Opossum
Pan.	<i>Gallus gallus</i>	Chicken
Pan.	<i>Leptotila verreauxi</i>	Verreaux's dove
Pan.	<i>Tyrannidae</i>	Small flycatcher
Pan.	? <i>Ameiva praesignis</i>	? Lizard
D. Guiana	? <i>Passalus</i>	? Beetle

## SPECIES OF UNCERTAIN STATUS

***Trombicula* (?*Eutrombicula*) *japa* (Ribeyro & Bambarén)**

*Leptus japonica* Ribeyro and Bambarén, 1922, Arch. Assoc. Peruana para el Prog. Cien. 2: 115.

*Trombicula japonica* (Ribeyro and Bambarén) Ewing, 1931, Proc. U. S. Nat. Mus. 80(8): 9. Radford, 1942, Parasitology 34: 57.

*Larva*.—Description incomplete.

*Adult*.—Unknown.

*T. japonica* causes human trombidiosis in Peru and it is said to be quite abundant in wooded areas in certain parts of the country. The original description and published figures do not permit generic assignment and no type specimens have been available to the author. The inclusion of this species in *Eutrombicula* is doubtful, but typical specimens of *T. alfreddugèsi* have been examined from Peru, and *T. japonica* might be a synonym. The authors of this species state that it is very closely related to *Microthrombidium ilalsahuata* of Mexico (syn. of *T. alfreddugèsi*).

A series of about a dozen poor specimens collected from the claw-toed lizard at Verrugas Cañon, Lima, Peru, are in the collection of the U. S. National Museum. These are definitely *Eutrombicula* and are either *T. japonica* or a new species related to *T. splendens*. These specimens have about 26 dorsal setae arranged 2-6-6-6-2-2 and 16 or 18 ventral setae arranged 2-2-6-2-2-(2). The scutum is relatively wide and narrow. Until *T. japonica* is definitely identified and described, no new species in this group can be described from the Peruvian area.

## DISTRIBUTION

## PERU

Valle de Chanchamayo to  
Rio Ucayali.

## HOSTS

Peru.....*Homo sapiens*.....Man  
Peru.....Domesticated animals  
Peru.....Wild animals

***Trombicula* (?*Eutrombicula*) *ophidica* Da Fonseca**

*Trombicula ophidica* Da Fonseca, 1932, Mem. Inst. Butantan 7: 151. Sig Thor & Willman, 1947, Das Tierreich 71b: 290.

*Eutrombicula ophidica* (Da Fonseca) Ewing, 1938, J. Wash. Acad. Sci. 28: 294. Radford, 1942, Parasitology 34: 66.

*Larva*.—Palpal claw with outer prong slightly subapical to inner prong. Palpi with genual setae two- to four-branched, ventral tibial setae four-branched. Scutum more or less *splendens* type shown in Fig. 1. Dorsal setae 22, ventral setae 20. Tibia III with one simple seta, tarsus III with one nude seta.

*Adult*.—Unknown.

A larval specimen of the type lot was kindly loaned by Dr. Flavio Da Fonseca. The specimen was not in good condition so that no definite decision could be reached concerning the affinities of the species. The diagnosis was written from the original description supplemented by recent observations.

## DISTRIBUTION

## BRAZIL

Sao Paulo: Pronissao, Mattao.

## HOSTS

Brazil.....*Ophis merremii*.....Boipeva snake

***Trombicula* (?*Eutrombicula*) *lahillei* (Sig Thor & Willman)**

*Microtrombidium brumpti* Lahille, 1927, Bol. Inst. Clin. Quir. B. Aires, 3: 773. André, 1930, Ann. Parasit. Hum. Comp. 8(3, 4): 355. (States type accidentally destroyed.)

*Trombicula brumpti* (Lahille) van Thiel, 1930, Parasitology 22: 353. Floch and Abonnenc, 1941, Inst. Pasteur Guyane et Terr. de l'Inini 20: 1. Radford, 1942, Parasitology 34: 58.

*Microtrombidium lahillei* Sig. Thor & Willman, 1947, Das Tierreich, 71b: 292. (*M. brumpti* Hirst, 1915, a synonym of *T. akamushi* preoccupies *M. brumpti* Lahille, 1927, so *M. lahillei* nomen novum was proposed.)

*Larva*.—Description incomplete.

*Adult*.—Unknown.

The status of the *Eutrombicula* in Argentina is not understood. *T. lahillei* and *Tetranychus molestissimus* Weyenbergh, 1876 (nomen nudum) are larvae known as "bicho colorado" which cause human trombidiosis. It is possible that they are the larval stage of *Trombicula coarctata*. They are very similar to *T. alfreddugèsi* and may be synonyms.

The original description of this species suggests a very distinctive mite having a setal formula of 4-8-2-6-6, including four humeral setae. Close examination of the published figures shows the type specimens to be fully engorged and with the typical setal formula of 2-6-6-4-2-2 of *T. alfreddugèsi*. The extra pair of small humeral setae are in the posi-

tion of and very likely represent the ventral coxal setae in a cleared specimen. The relationship of this species to *T. alfreddugèsi* could not be determined since the types are destroyed. *T. lahillei* is included in the subgenus *Eutrombicula* since the palpal claws are bifurcate with a smaller inner prong.

## DISTRIBUTION

## ARGENTINA

Villa Ballaster.

## HOSTS

Argentina.....*Homo sapiens*.....Man

***Trombicula* (?*Eutrombicula*) *coarctata* (Berlese)**

*Trombidium coarctatum* Berlese, 1888, Bull. Soc. Ent. Italiana Ann. 20: 9, 179. Berlese & Leonardi, 1901, Zool. Anz. 659: 17.

*Trombicula coarctata* (Berlese) Berlese, 1912, Redia 8: 91. Kitashima and Miyajima, 1918, (not of Berlese) Kitasato Arch. Exp. Med. 2: (2, 3). Ewing, 1920, (not of Berlese) Ann. Ent. Soc. Amer. 13: 382-384. Ewing, 1931, Proc. U. S. Nat. Mus. 80: 7. Ewing, 1933, Proc. U. S. Nat. Mus. 82: 2. Ewing, 1937, Proc. Biol. Soc. Wash. 50: 169. Ewing, 1938, J. Wash. Acad. Sci. 28: 292. Sig Thor & Willman, 1947, Das Tierreich 71b: 344.

*Larva*.—Unknown.

*Adult*.—Description incomplete.

The adults of this species were the first trombiculid adults seen by Berlese who founded the genus *Trombicula*. No specimens have been available for comparison with *T. alfreddugèsi* which this species appears to resemble closely. If these species are found to be the same, the name of our most common North American chigger would have to be changed again. *T. coarctata* is placed in the subgenus *Eutrombicula* because the eyes are located postero-laterad to the sensillary area, and because the body size, leg, and other measurements are similar.

## DISTRIBUTION

## ARGENTINA

Buenos Aires.

S. Pedro Missiones.

## PARAGUAY

Rio Apa (type locality).

## CHILE

Temuco.

## HOSTS

Unknown.

***Trombicula* (?*Eutrombicula*) *manriquei* Ewing**

*Trombicula manriquei* Ewing, 1937, Proc. Biol. Soc. Wash. 50: 169. Boshell and Kerr, 1942, Rev. Acad. Colomb. Cien. Exact., etc., 5: 9.

*Larva*.—Unknown.

*Adult*.—Description incomplete, type specimen not in good condition.

The single adult type specimen in the U. S. National Museum was collected from humus in a tree hole in Colombia. The original description states that no eyes are present and that posterior lobes are absent in the pseudostigmatic area. Examination of the type reveals a definite pair of eyes located postero-laterad to the sensillary bases and dorsal posterior lobes are present on the saddle as shown in Fig. 12. The sensillary bases are 44  $\mu$  in width and the longest posterior body

hairs are 73  $\mu$  in length. The nude apical setae on the tarsi cannot be counted, and other diagnostic characters cannot be distinguished so that identification cannot be made with certainty. It is most closely related to *T. alfreddugèsi* and may be a synonym, but more specimens and rearing of larvae are necessary before this can be established.

#### DISTRIBUTION

##### COLOMBIA

Meta: Villavicencio.

##### HOSTS

Unknown.

#### Acknowledgments

This study was carried on at the Medical Division, Army Chemical Center, Maryland, and at the Rocky Mountain Laboratory, U. S. Public Health Service, Hamilton, Montana. The author takes pleasure in acknowledging the assistance and suggestions of Drs. E. W. Baker, J. M. Brennan, L. E. Chadwick, H. S. Fuller, C. H. Kennedy, G. M. Kohls, C. B. Philip, and G. W. Wharton. The illustrations were drawn by Miss Alma D. Dinehart, U. S. Public Health Service, Hamilton, Montana, and by the author. Collections of mites were made while on duty in Panama in the U. S. Army, and in Venezuela while a member of an FAO United Nations Mission.

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ATLAS DE LOS ANOFELINOS SUDAMERICANOS, by ROBERTO LEVI CASTILLO. 207 pages, 354 figures. Sociedad Filantrópica del Guayas, Guayaquil, Ecuador. Price, \$10.00.

This is not an atlas in the same sense as Ross and Roberts' atlases of the mosquitoes or Ferris' atlas of the scale insects. It is an attempt to facilitate identification of the South American anophelines, with an avoidance, so far as possible, of the more difficult technical characters, so that a relatively inexperienced worker may be able to distinguish the malaria-transmitting species from one another and from those that are of little or no importance in this respect.

The work includes a discussion of the zoogeographical distribution of the South American species (pp. 7-19), a section on bionomics (pp. 20-25), a tabulation of the larval breeding places and adult habitats of the various species (pp. 26-31), and of the distribution of the malaria-transmitting species (pp. 32-33), and a reproduction of the more important parts of Gabaldon's (1945) biostatistical methods (pp. 34-50). The body of the work (pp. 51-160) consists of a description of the eggs, larvae, pupae, and adults of the genera (*Chagasia* and *Anopheles*) and of the subgenera of *Anopheles*, together with the keys to the genera, subgenera, and species, and the illustrations. This is followed by a bibliography covering the South American forms (pp. 161-206).

The keys are puzzling to the reviewer, in spite of twenty years' experience in the constant use of keys; it is hard to imagine, therefore, how they might be very useful to the inexperienced worker. The illustrations will help to atone for this deficiency, and the wealth of them is commendable. However, in some cases too great reduction has caused loss of detail or obscuring of the reference symbols; furthermore, some illustrations are too sparingly labelled or explained. Though the illustrations are on a good grade plate paper, the rest of the work is printed on a pulp paper of doubtful durability.

The sale of this work will undoubtedly suffer because of its price. It is useful, however, to have this information under one cover, and the Latin American malariologist will profit by having a manual for anopheline identification written in Spanish.—M. T. J.

# METEORUS ARGYROTAENIAE, A NEW SPECIES OF BRACONIDAE PARASITIC ON THE ORANGE TORTRIX<sup>1</sup>

CARL JOHANSEN,

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In the course of investigations of the orange tortrix, *Argyrotaenia citrana* (Fern.) on red raspberry at Puyallup, Washington, in 1948, a new species of the braconid genus *Meteorus* was found. This species was first noticed in the raspberry fields about the middle of April, the pupae of the parasite occurring in the tied-leaf nests of the orange tortrix caterpillars. The degree of parasitism had increased to 15-50% in some fields by the last week in July and showed evidence of giving partial control of the orange tortrix in certain fields during the picking season.

The same species was also found in the nests of an undetermined leaf-roller on plane tree at Vancouver, B. C., June 16, 1948.

## *Meteorus argyrotaeniae* n. sp.

*Female*.—Length 4.2-4.6 mm. Face punctate, opaque. Ocelli moderate, 0.11 mm. in diameter, ocellar-ocular line about one and one-third times diameter of median ocellus; vertex smooth and polished; temples polished. First flagellar segment of antenna about as long as scape and pedicel together; antennae 30- to 35-segmented, about as long as the body. Mesoscutum finely rugulose medially behind median lobe, lobes practically smooth and shining and well set off with sharp notaulices; propodeum rugose with irregular carinae and a channeled posterior face, dorsal face usually with large smooth areas; lateral face of pronotum smooth and shining with only a few short rugae medially; mesopleuron smooth with a crenulate furrow; metapleuron finely, confluent punctate. Wings with stigma large, nearly triangular; first abscissa of radius much shorter than second, third abscissa of radius going nearly to extreme apex of wing, second abscissa of radius shorter than second intercubitus, recurrent vein entering first cubital cell near first intercubitus, lower abscissa of basella subequal to, or slightly shorter than nervellus, radial cell large, extending nearly to apex of wing, radiellian cell narrowing towards the apex with no indication of a cross-vein. Posterior coxa longer than the respective trochanter, sparsely rugulose and shining; posterior femora sparsely rugulose; inner spur of the hind tibia one-third as long as the basitarsus. First abdominal tergite striate with two large dorsal fossae on petiole, the ventral margins of the tergite widely separated; remainder of abdomen smooth and polished; ovipositor sheath 1.7 mm. in length, nearly as long as the abdomen.

Brown or brownish yellow; scape of antenna pale brown, the rest darker; mandibles testaceous with darker tips; head testaceous, often

<sup>1</sup>Published as Scientific Paper No. 836. Agricultural Experiment Stations, Institute of Agricultural Sciences, State College of Washington, Pullman.

varied with brown or black; compound eyes black; prothorax testaceous, darker dorsally; mesothorax and metathorax pale brown, becoming almost black dorsally; wings hyaline, stigma pale; legs entirely pale brown and testaceous; first abdominal tergite black above; rest of abdomen testaceous, darker beneath and at posterior tip, opaque stramineous above; ovipositor pale brown. The cocoon is very thin and milky white in color.

*Types*.—Holotype, female, July 14 (emerged July 25), 1948, U. S. N. M. No. 59163; Paratopotypes, 14 females; Paratypes, 4 females.

*Type locality*.—Puyallup, Washington.

*Host*.—*Argyrotaenia citrana* (Fern.).

Described from 19 female specimens collected by the author at Puyallup, Washington, July 7, 14, 26, and 28 and August 6, 1948, as cocoons (emerged July 25, 28, 29, 30, August 2, 3, 12, 24, 1948); and at Vancouver, B. C., June 16 in host larvae and as cocoons (emerged July 1, 3, 5, 6, 1948).

This species will work out to couplet 8 in Muesebeck's key (Proc. U. S. Nat. Mus. 63(2): 1-44 (1924). It agrees in this couplet most nearly with *Meteorus communis* Cresson; however, the venter of the petiole at its base is rather coarsely roughened in *M. communis*, but only finely rugoso-punctate in *M. argyrotaeniae*, and the ovipositor sheath of *M. communis* is about half as long as the abdomen, as compared with more than three quarters of the length of the abdomen in *M. argyrotaeniae*.

This species is similar to *M. trachynotus* Viereck; however, the stigma of *M. trachynotus* is brown, pale at the base, that of *M. argyrotaeniae* is pale throughout or with darker margins; the first abscissa of radius in *M. trachynotus* is nearly or quite as long as the second whereas in *M. argyrotaeniae* it is much shorter than the second; and usually the propodeum is more closely and more coarsely rugose in *M. trachynotus*.

I wish to thank Mr. C. F. W. Muesebeck for criticism and suggestions and Dr. M. T. James for critical reading of this manuscript.

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INSECT DRUMMERS, A STUDY ON THE MORPHOLOGY AND FUNCTION OF THE SOUND-PRODUCING ORGAN OF SWEDISH AUCHENORRHYNCHA, by FREJ OSSIANILSSON. Opuscula Ent., Supplementum X, 146 pages, 13 plates, 1 text figure. 1949.

The sound-producing organ of the cicadas is well-known, but there has previously been but little information available concerning the poorly-known comparable mechanism of the other Auchenorrhyncha. Unlike that of the cicadas, this is a stridulatory organ. On the basis of the study of 79 Swedish species, representing 15 of the 21 families recognized by him, the author concludes that, since the males of all of these possess an organ homologous in its essential parts with the tymbal mechanism of the Cicadidae, the possession of such an apparatus is general among the Auchenorrhyncha.

The author worked with live insects as well as with preserved specimens. After the more usual morphological descriptions (pp. 15-53), he devotes a chapter to the description of the calls (pp. 54-99), which he attempts to imitate orthographically and with designation of pitch, as well as by radiographic presentation (plates 12-13). His techniques are fully described.

This appears to be a scholarly study of a little-known phenomenon.—M. T. J.

# A REVISION OF THE GENERA AND OF THE AMERICAN SPECIES OF TRYPHONINI

(Hymenoptera: Ichneumonidae)

## PART I

HENRY K. TOWNES AND MARJORIE C. TOWNES,

State College, Raleigh, North Carolina

This revision includes the species of the tribe Tryphonini occurring in the Western Hemisphere. Most of the tribe is in the temperate and cold regions of the northern hemisphere, and in America, only six species are known from south of the United States. All of the genera and subgenera at present recognized occur in America except the subgenus *Tryphon*, which in this paper is keyed out and discussed to make the scope of the generic treatment worldwide.

This paper is based largely on the Townes collection, greatly supplemented by loans from the U. S. National Museum, the Canadian National Collection, Cornell University, and other collections. The Swedish National Museum and the British Museum lent critical genotypes and other species. The complete list of American collections studied is as follows:

Townes Collection, Raleigh, North Carolina.  
U. S. National Museum, Washington, District of Columbia.  
Canadian National Collection, Ottawa, Ontario.  
Cornell University, Ithaca, New York.  
Academy of Natural Sciences, Philadelphia, Pennsylvania.  
University of Alberta, Edmonton, Alberta.  
California Academy of Sciences, San Francisco, California.  
University of Minnesota, St. Paul, Minnesota.  
Ohio State University, Columbus, Ohio.  
Harvard University (M. C. Z.), Cambridge, Massachusetts.  
Oregon State College, Corvallis, Oregon.  
Illinois Natural History Survey, Urbana, Illinois.  
University of Kansas, Lawrence, Kansas.  
University of California, Berkeley, California.  
Collection of R. R. Dreisbach, Midland, Michigan.  
Collection of R. M. and G. E. Bohart, Davis, California.  
Collection of R. T. Mitchell, Bowie, Maryland.  
Collection of H. H. Swift, New York City, New York.

In the lists of specimens studied, institutional collections are referred to by the city in which each is located (*i.e.*, Philadelphia for the Academy of Natural Sciences of Philadelphia, Berkeley for the University of California, etc.). These designations are used because they seem more generally intelligible than such abbreviations as I. N. H. S. and

A. N. S. P., and because the city in which a public collection is located is less likely to change than is the name of the institution housing it. Private collections are referred to by the name of the owner. In cases where the authors' collection contains a number of paratypes, some of these will be distributed to other collections.

We are indebted to the Division of Insect Identification of the U. S. Bureau of Entomology and Plant Quarantine and to the U. S. National Museum for the use of bibliographic and library facilities. Many collectors have contributed valuable material for this study. Among them are J. G. Rempel, E. H. Strickland, R. R. Dreisbach, C. E. Michener, H. R. Foxlee, R. M. Bohart, and G. E. Bohart. To these and others we wish to express our thanks.

The tribe Tryphonini is a moderately distinct group, for the Ichneumonidae, but it and the subfamily to which it belongs are difficult to define. Since the authors do not follow the conventional definitions of either group it is, however, necessary to make some statement of the limits used and of some of the supporting characters, although the definition of the subfamily can not at present be made both adequate and practical. To compensate partially for the difficulty of defining the Tryphonini, habitus figures of five of the genera are given (figs. 1, 12, 32, 42, and 43). With these and the characters discussed below, the student should be able to recognize members of the tribe.

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### Subfamily Tryphoninae

As stated above, present knowledge does not permit a clean definition of the subfamily Tryphoninae, nearly every distinctive adult character being subject to exceptions. The Tryphoninae is one of a group of subfamilies that is normally ectoparasitic; whose larvae, as far as known, have the inner end of the maxillary sclerome adjacent to the labial sclerome near or below its middle rather than near its top, and whose adults have the ovipositor without a subapical dorsal notch and usually with an apical series of oblique ridges or teeth. Sometimes when the ovipositor has a subapical elevation, the summit of the elevation may have a weak notch. When the apical part of the ovipositor is unusually slender, these group characters are often obliterated. Another adult character of some value in a definition of these subfamilies is the usual absence of a small tooth on the outer side of the apical rim of the front tibia.

The Tryphoninae differ from other subfamilies of the ectoparasitic series in having the egg with a stalk by which it is attached to the skin of the host (figs. 1, 4, 5, 34, and 35). Some of the Tryphoninae of the tribe Cteniscini have the stalk lost or modified, and by them the entire egg is imbedded in the host's skin. Distinctive characters of adults of the Tryphoninae are: areolet, when present, nearly always oblique, with the first intercubitus shorter than the second; male antenna without tyloids; first tergite usually with glymmae and nearly always with the spiracles before the middle; and tarsal claws usually more or less distinctly pectinate and never with a large basal or subapical tooth. Below is a key to the tribes of the subfamily, and following this a list of the known genera of each.

## ARTIFICIAL KEY TO THE TRIBES OF TRYPHONINAE

1. Hind tibia with one spur or none. . . . . 2  
Hind tibia with two spurs. . . . . 3
2. Hind tibia with a spur that is longer than the apical diameter of the tibia; middle tibia with two spurs; spiracle of first tergite near its apical 0.4; clypeus with a blunt median point. . . . . **Sphinctini**  
Hind tibia without a spur; middle tibia with one spur; spiracle of first tergite at or in front of its middle. . . . . **Cteniscini**
3. Prepectal and occipital carinae absent; propodeum without carinae; apical margin of clypeus with a median pair of blunt teeth; wings blackish. . . . . **Boëthini**  
Prepectal carina, or occipital carina, or both present. . . . . 4
4. The part of the first tergite in front of its spiracle at least 1.6 as long as it is wide at its narrowest point; first tergite without a lateral basal corner projecting above the glymma; second recurrent vein with two bullae; propodeum with at least the petiolar area defined by carinae; areolet absent except in some species of *Eclytus*. . . . . **Eclytini**  
Without the above combination of characters. . . . . 5
5. First tergite without a glymma (a lateral groove between the spiracle and the base of the tergite) and solidly fused to the first sternite; fore wing 2.5 to 4.5 mm. long. . . . . 6  
First tergite with a glymma and more or less free from the first sternite; fore wing 2.5 to about 25 mm. long. . . . . 7
6. Labrum projecting conspicuously beyond the truncate apex of the clypeus as a transverse plate, never hidden by the mandibles. . . . . **Adelognathini**  
Labrum not or hardly visible, concealed by the clypeus and mandibles. . . . . **Phrudini**
7. Propodeum without carinae, or with a single transverse carina that is usually interrupted into two lateral crests; when with a transverse carina or lateral crests, the propodeum is always transversely striate basad of these; spur of front of tibia with its distal portion straight or slightly outcurved, its antennal brush ending considerably before the apex of the spur. . . . . **Phytodietini**  
Propodeum with carinae, usually with longitudinal as well as one or more transverse carinae, never transversely striate; spur of front tibia evenly curved, its antennal brush extending nearly to its apex. . . . . 8
8. Labrum projecting conspicuously beyond the apical margin of the clypeus, which is thin and not turned under; areola separated from the basal area, elongate pentagonal, its base reduced almost to a point. . . . . **Stilbopini**  
Labrum not visible, concealed beneath the clypeus, which has its true apical edge turned under to leave a subapical part as the apparent apical margin; areola not separated from the basal area except in the Patagonian genus *Scolomus*. . . . . 9
9. Areolet sessile above or sometimes subpetiolate, with the recurrent vein received much nearer to the second intercubitus than to the first; occipital carina going directly to the base of the mandible or joining the hypostomal carina almost at the mandible; fore wing about 2.5 to 4.2 mm. long. . . . . **Grypocentrini**  
Arolet petiolate, subpetiolate, or absent, or if sessile (in *Scolomus*) then the recurrent vein received about midway between the two intercubital veins; occipital carina joining the hypostomal carina, or sometimes incomplete below, when complete the juncture distant from the mandible by at least 0.2 the basal width of the mandible; fore wing 3.5 to 9 mm. long. . . . . **Tryphonini**

**STILBOPINI.** *Stilbops* is the only genus. *Aphanoroptrum* is hereby synonymized with *Stilbops* and its only species, *Pimpla abdominalis* Gravenhorst 1829, referred to *Stilbops* (new combination). The tribe is placed in the Tryphoninae provisionally.

**ADELOGNATHINI.** The genera included are *Adelognathus*, *Pammicra*, and *Cnemischys*.

PHRUDINI. *Phrudus* is the only genus. The tribe is placed in the Tryphoninae provisionally.

SPHINCTINI. *Sphinctus* is the only genus.

PHYTODIETINI. This tribe includes *Phytodietus*, *Weisia*, and *Netelia*. *Weisia* is known to the authors only by descriptions.

ECLYTINI. This tribe includes *Eclytus*, *Atopotrophos*, *Neliopisthus*, *Campothreptus*, *Hybophanes*, *Thymaris*, and an undescribed Nearctic genus. In 1945 the authors<sup>1</sup> included the then monobasic *Chiloplatys* also, but knowledge of a second species of the genus indicates that *Chiloplatys* is better placed in the Tryphonini.

GRYPOCENTRINI. This tribe includes *Grypocentrus*, *Idiogramma*, and an undescribed Nearctic genus.

BOETHINI. *Boëthus* is the only genus.

TRYPHONINI. This tribe includes *Polyblastus*, *Ctenochira*, *Erromenus*, *Monoblastus*, *Thibetoides*, *Chiloplatys*, *Dyspetus*, *Scolomus*, *Cosmoconus*, and *Tryphon*. The genera are treated taxonomically in this paper.

CTENISCINI. The cteniscine genera recognized at present are *Exenterus*, *Acrotomus*, *Cteniscus*, *Eridolius*, *Diaborus*, *Smicroplectrus*, *Exyston*, *Tricampius*, *Picroscopus*, and *Anisoctenion*. The tribe is very close to the *Polyblastus* group of the Tryphonini, as *Cteniscus* is hardly distinguishable from *Polyblastus* except on tibial spur and ovipositor characters. The tribal name "Cteniscini" is preferred to "Exenterini" because the former name is based on that of the oldest included genus.

### Tribe Tryphonini

Members of this tribe are typically stout-bodied species with the propodeum usually rather completely areolated, and the first tergite usually broad and with a pair of median dorsal carinae. The ovipositor is usually short. The key to the tribes and the habitus figures of representative genera (figs. 1, 12, 32, 42, and 43) will assist in recognizing members of the tribe. As far as known all species are parasites of *Tenthredinidae*, the stalked egg being attached to the larva but the parasite's development delayed until after the host spins its cocoon.

Previous taxonomic history in America comprises the proposal of new specific and an occasional new generic name by Cresson in 1864, 1868, 1874, and 1878; by Provancher in 1874, 1875, 1879, 1883, and 1886; by Cameron in 1886; by Ashmead in 1890, 1901, and 1902; by Fyles in 1893; by Davis in 1897 and 1898; by Brues in 1907 and 1919; by Hall in 1919; by Viereck in 1924; and by Townes and Townes in 1945. In 1897-98, Davis included a revision of the Nearctic species of the tribe in his treatment of the Nearctic Tryphoninae (Trans. Amer. Ent. Soc. 24:193-347). Other literature on the tribe includes distributional records, mostly included in regional lists of insects, and host records for four of the species. In 1944 Townes (Mem. Amer. Ent. Soc. 11:147-158) catalogued all of the literature on the Nearctic species and proposed new synonymy and generic placements. Persons interested in a complete record of the literature are referred to this catalogue.

<sup>1</sup>Townes and Townes, 1945. Bol. Ent. Venez., 4: 41-52.

In the present paper, only the references to original descriptions are included for Nearctic species, but the scant literature on the Neotropical species is given complete.

Except for *Tryphon montezuma* Cameron, the types of all specific names proposed for American species were studied in 1941 and some of them again at later dates. Mr. J. F. Perkins of the British Museum has obligingly compared specimens with the types of *Tryphon montezuma*. All genotype species but those of *Trichocalymma*, *Ctenochira*, *Ctenacme*, *Ctenacmus*, *Monoblastus*, and *Nemioblastus* have been seen. These names have been placed after study of the literature with the application of *Trichocalymma* remaining somewhat questionable<sup>2</sup>.

A number of American species have been erroneously referred to this tribe. The Nearctic species among them have been placed elsewhere in the previously mentioned catalogue. A few described from Mexico by Cresson have been placed elsewhere in another recent paper (Townes, 1946. Bol. Ent. Venez. 5:29-63). Other species, presumably all misplaced, are as follows:

*Polyblastus? aztecus* Cameron, 1886. Biol. Centr.-Amer., Hymen.

1:287. Type: ♂, Northern Sonora, Mexico (type lost).

*Tryphon cerberus* Dewitz, 1881. Berlin. ent. Ztschr. 25:207.

Type: ♂, Puerto Rico (Berlin).

*Tryphon cinctus* Cresson, 1865. Proc. Ent. Soc. Philadelphia 4:16.

Type: ♂, Cuba (Havana).

*Tryphon? claviventris* Cresson, 1865. Proc. Ent. Soc. Philadelphia

4:17. Type: ♂, Cuba (Havana).

*Tryphon? exiguus* Cresson, 1865. Proc. Ent. Soc. Philadelphia

4:16. Type: ♀, Cuba (Havana).

*Tryphon lineolatus* Brullé, 1846. Hist. Nat. Insectes Hymén.

4:318. Type: ♀, Prov. des Mines, Brazil (?Paris).

*Tryphon mesoxanthus* Brullé, 1846. Hist. Nat. Insectes Hymén.

4:319. Type: ♀, Prov. de Goyaz, Brazil (?Paris).

*Tryphon? rufithoracicus* Cresson, 1868. Trans. Amer. Ent. Soc.

2:107. Type: ♂, Cuba (Havana).

The original descriptions of *Tryphon cerberus*, *T. lineolatus*, and of *T. mesoxanthus* indicate that they are more probably referable to *Colpotrochia* than to any tryphonine genus. The description of *Polyblastus aztecus* suggests that it belongs to the Ichneumoninae. Specimens answering to the description of *Tryphon claviventris* have been seen. These are a species of *Colpotrochia*, to which genus *claviventris* is hereby transferred. The descriptions of *Tryphon cinctus*, *T. exiguus*, and *T. rufithoracicus* give little hint of their proper systematic positions.

A few of the characters used in the descriptions may need explanation: The subtegular ridge is an elevated part of the mesopleurum just below the tegula (figs. 2, 3, 11, 16, 17, 23 to 31, and 44 to 48). It often assumes special shapes and thus provides taxonomic characters. The length of the fore wing, used as an indication of size, is taken from the apex of the tegula to the tip of the wing. The length of the face is taken from the lower margin of the antennal sockets to the clypeal

<sup>2</sup>*Polyrhysis*, commonly referred to the Tryphonini, is a mesoleiine genus whose genotype (*Tryphon tenuicornis* Gravenhorst) is congeneric with the genotype of *Synoeetes*, with which *Polyrhysis* is hereby synonymized.



foveae, and its width at its narrowest point. The length of the first tergite is taken from the center of the insertion of the large extensor muscle to its apex on the median line. The length of the petiolar area is its extreme length, measured to its latero-ventral corners. The length of most other bilaterally symmetric structures is taken on their midlines and their widths at their widest points.

#### ARTIFICIAL KEY TO THE GENERA OF TRYPHONINI

1. Areolet broadly sessile above; mesopleurum just below the wing base with a strong, laterally-projecting claw (fig. 43). Patagonian... **Scolomus**  
 Areolet petiolate or subpetiolate above (figs. 1, 12, 32, and 42), or absent; mesopleurum just below the wing base without a laterally projecting claw.....2
2. First and second tergites completely fused, though separated by a sharp groove; apical part of abdomen curled under (fig. 32). Northwestern United States..... **Thibetoides**  
 First and second tergites separated by a moveable suture; apical part of abdomen not curled under (figs. 1, 12, and 42).....3
3. Frons with a median horn or nipple just above the antennal sockets, the horn not hollowed out above; abdomen in the American species black and yellow. Holarctic..... **Cosmoconus**  
 Frons without a median horn or nipple except in the European *Monoblastus brachycanthus*, which has the horn hollowed out above; abdomen in the American species black, ferruginous, or black and ferruginous.....4
4. Second recurrent vein with a strong zig-zag near its center (fig. 42); tarsal claws pectinate only at the very base, apparently simple. **Tryphon**  
 Second recurrent vein without a zig-zag, or when with a zig-zag, with a much weaker one than is shown in fig. 42; tarsal claws usually pectinate on the basal 0.4 or more.....5
5. Upper margin of mesopleurum produced upwards and outwards as a lamella that is in contact with the lower edge of the tegula when the latter is not raised (figs. 16 and 17); ovipositor and its sheath upcurved (figs. 12 to 15 and 18 to 21). Holarctic..... **Erromenus**  
 Upper margin of mesopleurum not capable of making contact with the lower margin of the tegula; ovipositor straight or downcurved (figs. 1, 4, 5, 8, 22, 33, and 34).....6
6. Areolet present, rhombic, longer than high, its intercubital veins of nearly equal length and nearly equidistant from the second recurrent vein; occiput behind with a more or less distinct median notch. Holarctic, **Dyspetus**  
 Areolet present or absent, when present oblique and subtriangular, the second intercubital vein longer than the first and nearer than the first to the second recurrent vein (fig. 1).....7
7. Costula present, joining the petiolar area near its base; ovipositor with a blunt point (figs. 4 and 5). Nearctic..... **Polyblastus (Cophenchus)**  
 Costula present or absent, when present joining the areola; ovipositor with a sharp point (figs. 1, 8, and 22).....8
8. Clypeus very large, weakly arched longitudinally so that its profile is almost straight; lower part of hypostomal carina raised as a triangular tooth; length of ovipositor about 2.0 the apical depth of the abdomen. Mexican..... **Chiloplatys**  
 Clypeus smaller, strongly arched longitudinally so that its profile is quite convex; lower part of hypostomal carina not raised as a triangular tooth; length of ovipositor less than 1.5 the apical depth of the abdomen.....9
9. Tarsal claws strongly pectinate nearly or quite to the apex; second tergite without a transverse shallow groove; cheek less than 0.3 as long as the basal width of the mandible; ovipositor usually carrying a number of eggs (fig. 1). Holarctic..... **Polyblastus** (except the subgenus *Cophenchus*)  
 Tarsal claws pectinate on at most their basal 0.7 or the second tergite with a postmedian broad, shallow, transverse impression, or the cheek more than 0.24 as long as the basal width of the mandible; ovipositor carrying only one egg at a time, usually without an egg.....10

10. Distance between posterior condyles of the two mandibles conspicuously greater than that between the eyes at the level of the clypeal foveae; outer face of mandible at its basal 0.2 flat in cross section or weakly convex or concave, with large punctures; tarsal claws not pectinate to the apex; ovipositor straight, its sheath narrow (fig. 22). Holarctic,

**Monoblastus**

Distance between posterior condyles of the two mandibles less than or subequal to that between the eyes at the level of the clypeal foveae; outer face of mandible at its basal 0.2 strongly convex in cross section, with only small inconspicuous punctures; tarsal claws pectinate nearly or quite to the apex; ovipositor decurved, its sheath broad (fig. 8). Holarctic,

**Ctenochira**

## Genus *Polyblastus*

Figures 1 to 5

*Ovipositor bearing numerous eggs* (fig. 1); *tarsal claws strongly pectinate to the apex except in P. flexus; clypeus broad.*

Fore wing 4.0 to 7.5 mm. long; body rather short and stout, the head and wings large, and the legs relatively slender; clypeus often quite large, evenly convex or with a weak median transverse ridge; median third of apical margin of clypeus usually somewhat turned outwards and fringed with closely spaced long setae; cheek 0.15 to 0.30 as long as the basal width of the mandible; posterior mandibular condyles separated from each other by a distance subequal to or somewhat greater than that between the eyes at the level of the clypeal foveae; outer face of mandible at its basal 0.2 more or less convex, with scattered punctures; postero-lateral corner of pronotum not unusually heavy nor projecting; subtegular ridge unspecialized (fig. 3) or in some species of the subgenus *Labroctonus* with a thin upright lamella that almost reaches the lower edge of the tegula (fig. 2); tegula convex; areolet present or absent, when present oblique; second recurrent vein evenly curved, with two well-separated bullae; nervellus broken at its lower 0.2 to 0.45; tarsal claws strongly pectinate to the apex (except that in *P. flexus* they are apparently simple); second tergite without grooves, impunctate, polished to mat and rugulose; ovipositor sheath narrowly clavate, flexible only at the base, projecting conspicuously beyond the end of the abdomen; ovipositor straight (or in *P. flexus* strongly decurved), 0.35 to 1.1 as long as the abdomen, capable of carrying a large number of eggs (figs. 1, 4, and 5).

This genus, *Ctenochira*, and *Erromenus* appear to be related, but may be grouped together only by characters which are rather vague or subject to so many exceptions as to be hardly worth discussing. Among these may be mentioned the rigid ovipositor sheath flexible only at the base, the (usually) strongly pectinate tarsal claws, and the widely separated bullae of the second recurrent vein. *Polyblastus* seems the least specialized of the three. It is divisible into three subgenera.

### KEY TO THE SUBGENERA OF POLYBLASTUS

1. Areolet absent; eggs infusate. . . . . subgenus **Labroctonus**  
Arolet present; eggs whitish. . . . . 2
2. Costula strong, weak, or absent, when present joining the combined areola and basal area; ovipositor with a sharp point (fig. 1). . . subgenus **Polyblastus**  
Costula weak, joining the petiolar area near its base; ovipositor with a blunt point (figs. 4 and 5). . . . . **Cophenchus**, new subgenus

Subgenus **Polyblastus**

## Figure 1

*Polyblastus* Hartig, 1837. Wieg. Arch. Naturg. 3: 155.

Type: (*Tryphon varitarsus* Gravenhorst) = *strobilator* Thunberg. Designated by Viereck 1912.

Areolet present; hind tibia either black with a white median band (the black and white color more or less replaced by ferruginous in some specimens of *Polyblastus pedalis* and the hind tibia uniformly black in the European *Polyblastus cothurnatus*) or whitish at the base and blackish at the apex; costula strong, weak, or absent, when present meeting the combined areola and basal area; ovipositor tapered to a sharp point; shell of eggs whitish or pale bluish.

The species of this subgenus known to us divide into two species groups, each with two definable subgroups.

1. *Strobilator* group. Hind tibia black with a white median band (but the black and white more or less replaced by ferruginous in some specimens of *pedalis* and the hind tibia uniformly black in the European *cothurnatus*); nervellus broken at its lower 0.3 to 0.45, moderately inclivous; costula strong, meeting the combined areola and basal area about 0.35 from its apex. Included are the Nearctic *tibialis* and *pedalis*, the Holarctic *strobilator*, *palaemon*, and *carbonarius*, and the European *cothurnatus* Gravenhorst 1829. These may be divided into subgroups, putting *strobilator*, *cothurnatus*, and *tibialis* together, and *palaemon*, *pedalis*, and *carbonarius* together. The characters distinguishing the two subgroups are pointed out in couplet 2 of the key to species.

2. *Fulvilinealis* group. Hind tibia whitish at the base and blackish at the apex; nervellus broken at its lower 0.2 to 0.35, strongly inclivous; costula strong, weak, or absent, when present joining the combined basal area and areola at about 0.4 from its apex. Included are the Nearctic *atrox* and *fulvilinealis*, the Holarctic *wahlbergi*, and the European *pinguis* Gravenhorst 1829. These may be divided into subgroups, putting *atrox* and *pinguis* together and *fulvilinealis* and *wahlbergi* together. The characters distinguishing the two subgroups are pointed out in couplet 6 of the key to species.

KEY TO THE AMERICAN SPECIES OF THE  
SUBGENUS POLYBLASTUS

1. Hind tibia blackish with a pale median band, or almost uniformly ferruginous; nervellus broken at its lower 0.3 to 0.45, moderately inclivous (*strobilator* group).....2
- Hind tibia basally whitish and apically blackish or infusate; nervellus broken at its lower 0.2 to 0.35, strongly inclivous (*fulvilinealis* group).....6
2. Abdomen partly ferruginous, or sometimes entirely black; first tergite about 1.7 to 2.2 as long as it is wide at the apex; inner edge of second lateral propodeal area about 0.4 as long as the basal edge (*strobilator* subgroup).....3
- Abdomen entirely black; first tergite about 1.2 to 1.4 as long as it is wide at the apex; inner edge of second lateral propodeal area about 0.3 as long as the basal edge (*pedalis* subgroup).....4
3. Hind coxa entirely ferruginous; tegula yellow; basal 0.25 or less of clypeus black.....1. *tibialis*
- Hind coxa entirely or largely black; tegula blackish; basal 0.3 or more of clypeus black.....2. *strobilator*

4. Clypeus with its basal 0.2 or less black; under side of scape whitish,  
Clypeus with its basal 0.35 or more black; under side of scape black.....5  
3. *palaemon*
5. Coxae ferruginous.....4. *pedalis*  
Coxae black.....5. *carbonarius*
6. Coxae and most of all femora black; petiole and propodeum mostly scabrous,  
with very heavy carinae; a robust species (*atrox* subgroup).....6. *atrox*  
Coxae and femora ferruginous or stramineous; petiole and propodeum  
mostly polished, with weaker carinae; more slender species (*fulvilinealis*  
subgroup).....7
7. Propodeum and pleura largely or entirely ferruginous; costula strong,  
Propodeum and pleura entirely black; costula weak or absent,  
7. *fulvilinealis*  
8. *wahlbergi rufescens*

### 1. *Polyblastus (Polyblastus) tibialis* Cresson

*Tryphon tibialis* Cresson, 1864. Proc. Ent. Soc. Phila. 3: 280. Type: ♀, Ill. (Philadelphia).

*Tryphon annulipes* Cresson, 1868. Trans. Amer. Ent. Soc. 2: 108. Type: ♀, Ft. Resolution, Great Slave Lake (Philadelphia).

*Prinopoda (!) media* Hall, 1919. Psyche 26: 158. Type: ♀, Machias, Me. (Cambridge).

*Second tergite usually ferruginous; hind coxa ferruginous.*

Fore wing about 6.0 mm. long. Structurally similar to *P. strobilator* except that the face is slightly less densely punctate and less densely hairy.

Colored as in *P. strobilator* except as follows: clypeus except for its basal 0.25 or less, at least the under side of scape and pedicel, postero-lateral corner of the pronotum, trochanters, and indefinite markings on the front and middle coxae yellowish; coxae ferruginous, the front and middle ones more or less yellowish.

*Variations:* Specimens from northwestern United States (Ashford and Westport, Wash. and Crescent City, Calif.) have the ferruginous markings of the abdomen reduced, sometimes to dark ferruginous margins at the base of the second tergite and at the apices of the second and third tergites. A series of specimens collected September 5, 1939 and June 21, 1940 on Pisgah Mountain, N. C. at 4800 to 5700 ft. are unusually slender and small (fore wing about 4.8 mm. long), and with tergites 2 to 4 pale ferruginous in the center and marked with fuscous along the sides. A specimen from Southbridge, Mass. is similar to those from Pisgah Mountain.

*Specimens:* Many males and females from ALBERTA (Bilby and Dapp); ARIZONA (near Alpine at 8200 ft. and Oak Creek Canyon); BRITISH COLUMBIA (Hundred Mile House, Likely, and Revelstoke in the Selkirk Mts.); CALIFORNIA (Coffee Creek at Big Flat in Trinity Co., Crescent City, and Redwood Creek in Humboldt Co.); COLORADO (Ft. Collins and Peaceful Valley); KANSAS (Lawrence); MAINE (Lincoln Co., Monmouth, and Southwest Harbor); MANITOBA (Churchill and Gillmann); MARYLAND (Takoma Park and 10 miles east of Washington, D. C.); MASSACHUSETTS (Holliston, North Adams, Southbridge, and South Hadley); MINNESOTA (Itasca Park, Kawishiwi River, and Pine Co.); NEW HAMPSHIRE (Jaffrey, Mt. Madison, and Pinkham Notch); NEW YORK (Bemus Point, McLean Reserve in Tompkins Co., Shokan, Troy, and Woodhaven); NORTH CAROLINA (Pisgah Mt. at 4800 to

5300 ft. and at 5000 to 5749 ft.); ONTARIO (Sudbury); OREGON (Siskyou Mts. in Jackson Co.); PENNSYLVANIA (Spring Brook); QUEBEC (Brome, Georgeville, Knowlton, St. Johns, Sherbrooke, and Stoneham); RHODE ISLAND (Hopkington, Kingston, and Westerly); VERMONT (Dummerston and Plainfield); WASHINGTON (Ashford, Quinault, and Westport) and WISCONSIN (Sawyer Co. and Trout Lake).

This species occurs from the Atlantic to the Pacific in the Transitional and Canadian zones. The record from Churchill, Man. indicates its presence in the Hudsonian Zone also. Its habitat is the heavy rank herbage and shrubs in or on the edge of moister woods, and often over patches of *Equisetum arvense*, where it is perhaps parasitic on the larvae of *Dolerus* that commonly infest this plant. Adults are commonest in June and early July. Early and late collecting dates of interest are: May 23 at Lawrence, Kans.; May 25 at South Hadley, Mass.; September 3 at Southbridge, Mass. and at Troy, N. Y.; and September 5 on Pisgah Mt., N. C. at 5000 to 5749 ft.

## 2. *Polyblastus (Polyblastus) strobilator* Thunberg

### Figure 1

*Ichneumon strobilator* Thunberg, 1882. Mém. Acad. Sci. St. Pétersburg 8: 270.

Type: ♂, no locality given (Upsala).

*Tryphon varilarsus* Gravenhorst, 1829. Ichneum. Europ. 1: 688, 2: 222. Types:

♂, ♀, central Europe (? Breslau).

*Erromenus annulipes* Ashmead, 1902. Proc. Wash. Acad. Sci. 4: 212. Type: ♀,

Popof Is., Alaska (Washington).

*Second tergite usually ferruginous; hind coxa black.*

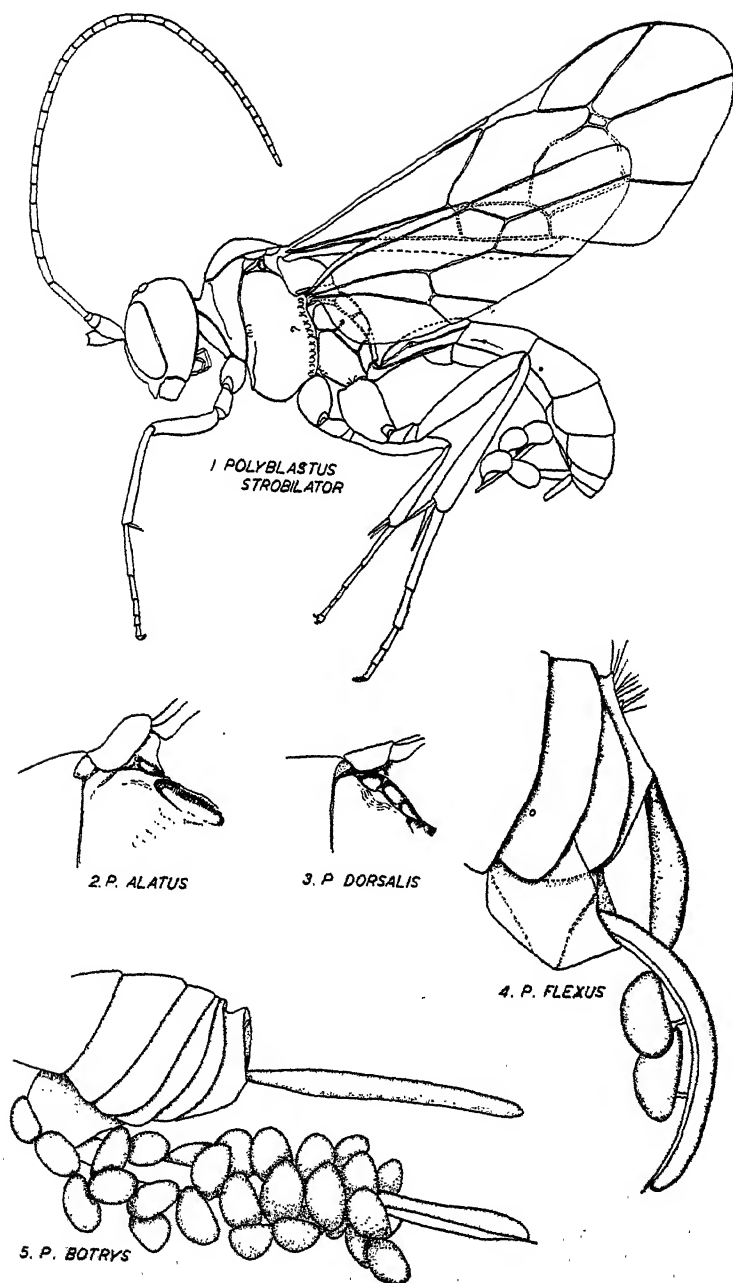
Fore wing about 5.8 mm. long; mesopleurum moderately punctate; propodeum and petiole subpolished; propodeum with sharp carinae, the costula strong; petiolar area hexagonal with rounded angles, usually without a median longitudinal carina, about 0.9 as long as the combined basal area and areola; first tergite about 2.1 (♂) or 1.8 (♀) as long as broad, rather weakly arched above, its dorsal carinae extending about 0.8 its length.

Black. Apical 0.6 of clypeus, legs except as noted below, and second and third tergites ferruginous; mandible except apical part, palpi, trochanters, fore and middle coxae of male, and indistinct markings on fore and middle tibiae and tarsi yellowish; tegula black; basal part of fore and middle coxae blackish; hind coxa black; hind first trochanter and base of hind femur infuscate; apex of hind femur black; hind tibia and tarsus black, yellowish white as follows: band occupying about 0.4 the length of the tibia centering just above the middle, tibial spurs, and basal 0.35 of first three tarsal segments.

*Variations:* The abdomen varies from entirely black (one specimen from Katmai, Alaska) to black with second and third incisures bordered with ferruginous (some specimens from Mt. Rainier, Wash. at 2700 ft.) to black with the second, third, and fourth, and extreme apex of first

## EXPLANATION OF PLATE I

FIG. 1. *Polyblastus strobilator*, ♀, side view. FIG. 2. *Polyblastus alatus*, subtegular ridge. FIG. 3. *Polyblastus dorsalis*, subtegular ridge. FIG. 4. *Polyblastus flexus*, ♀, end of abdomen. FIG. 5. *Polyblastus botrys* ♀, end of abdomen.



segment ferruginous (specimens from Sweden and from Stoneham, Que.). Occasional specimens from the West (Katmai, Alaska; some from Mt. Rainier, Wash. at 2700 ft.; Cloudcroft, N. M.; Boulder, Colo.; Pingree Park, Colo.; and at 11000 ft. in the Rocky Mt. National Park, Colo.) have the hind femur entirely black. The hind coxa may have as much as the apical 0.4 yellowish or ferruginous (most often in males from the East), and the scape may be yellow beneath. As a rule the black markings are most extensive in specimens from the West.

*Specimens:* Many males and females from: ALASKA (Anchorage, Fairbanks, and Katmai); ALBERTA (Bilby, Edmonton, and Slave Lake); BRITISH COLUMBIA (Agassiz, Chilcotin, Chilliwack, Clinton, Hope Summit, Hundred Mile House, Kaslo, North Vancouver, Revelstoke in the Selkirk Mts., and Vancouver Island); CALIFORNIA (Summit); COLORADO (Boulder, above timberline on Long's Peak Trail, Pingree Park, at 11000 ft. in Rocky Mt. National Park, and Rockwood); IOWA (Ames); MASSACHUSETTS (West Springfield); MICHIGAN (Crawford Co., Midland Co., Otsego Co., Roscommon Co., and Saginaw Co.); MINNESOTA (Itasca Park and Lake Itasca); MONTANA; NEW HAMPSHIRE (Base Station, Mt. Madison, and Randolph); NEW MEXICO (Cloudcroft); NEW YORK (southern Adirondack Mountains and Saranac Lake); ONTARIO (Bells Corners, Britannia, Ottawa, Sudbury, and Wabamie); OREGON (Aneroid Lake in the Blue Mountains at 7500 ft., Cannon Beach, Cornucopia at 7100 ft., Corvallis, Independence, Kiger's Island, Linn Co., Newport, Scappoose, Seaside, Wallowa Lake on the Aneroid Lake Trail, and Warrenton); QUEBEC (Burbridge, near Cookshire, Gracefield, Hull, Lac Mercier, Maniwaki, Montreal, Mt. Lyall at 1500 ft., and Stoneham); SASKATCHEWAN (Antelope Lake, Prince Albert National Park, Redberry, Saskatoon, and Waskesiu); and WASHINGTON (Arlington, Ashford, Chinook Pass summit, Eatonville, Elbe, Mt. Rainier at 2700 ft., 2900 ft., and 4700 ft., Snoqualmie Pass, and Westport).

This species occurs from the Atlantic to the Pacific in the Transitional, Canadian, and Hudsonian zones. In the East, it is mostly in the Canadian Zone and has not been taken south of Massachusetts, New York, Michigan, and Minnesota. In the West, it occurs southward to New Mexico and is common in the Transitional. Adults are on the wing throughout most of the growing season, being most common in the summer. Early and late collecting dates are April 8 at Kiger's Island, B. C.; May 2 at Scappoose, Oreg.; May 11 at Agassiz, B. C.; October 14 at Montreal, Que.; and October 19 at Chilliwack, B. C. The favored habitat is low damp spots among grasses and sedges. In suitable northern localities the species is often abundant. It is reported to be common over most of Europe, where it has been reared as a parasite of *Dolerus*. Judging from the adult habitat in America, this genus is probably its usual host.

### 3. *Polyblastus (Polyblastus) palaemon* Schiödte

*Polyblastus Palaemon* Schiödte, 1838. Rev. Zool. (Soc. Cuv.) 1: 140; 1839, Mag. de Zool. 1: ins. pl. 6-10: 13. Type: ♀, Denmark (? Copenhagen).

*Second tergite black; hind coxa ferruginous; under side of scape whitish.*

Fore wing about 5.0 mm. long. Structurally similar to *P. pedalis*, but slightly less robust and less strongly sculptured.

Colored as in typical *P. pedalis* except as follows: Clypeus except extreme base, entire under side of scape, mandible except the apical part, most of trochanters and front and middle coxae of the male, and the under side of the hind coxa of the male yellowish white.

Many features in the coloration of this species are like those of *P. tibialis*, perhaps indicating a close relationship with that species.

*Specimens*: 3♂, Slave Lake, Alta., Aug. 14, 1924, O. Bryant (Washington and Townes); ♀, The Pas, Man., July 31, 1937, R. H. Daggy (St. Paul).

The species occurs also in northern and central Europe.

#### 4. *Polyblastus (Polyblastus) pedalis* Cresson

*Tryphon pedalis* Cresson, 1864. Proc. Ent. Soc. Phila. 3: 273. Type: ♂, Ill. (Philadelphia).

*Bassus Bouleti* Provancher, 1874. Nat. Canad. 6: 32. Type: ♀, Que. (Quebec).

*Second tergite black; hind femur and coxa ferruginous; under side of scape black.*

Fore wing about 5.8 mm. long; mesopleurum moderately punctate; propodeum and petiole subpolished to somewhat mat and scabrous; propodeum with heavy sharp carinae, the costula strong; petiolar area hexagonal with sharp angles, usually with a median longitudinal carina, about 1.1 as long as the combined basal area and areola; first tergite strongly arched above, about 1.25 as long as broad, its dorsal carinae strong, extending about 0.85 its length.

Black. Apical 0.6 of clypeus, legs except hind tibia and tarsus, and apical 0.4 of mandible except for the black apical edge, ferruginous; basal 0.6 of mandible, palpi, tegula, bases of wings, and postero-lateral corner of pronotum white; apex of hind femur blackish; hind tibia and tarsus black, white as follows: a band occupying about 0.4 of the tibia, centering just above the middle; basal 0.33 of basitarsus, basal 0.25 of second tarsal segment, and the extreme base of the third tarsal segment; hind tibial spurs whitish with their apices dusky.

*Variations*: A number of specimens from Mt. Rainier, Wash. and the vicinity have the abdomen unusually broad, perhaps because they developed in very short host cocoons. Many specimens from western Washington, Oregon, and British Columbia have the contrasted black and white of the hind tibia and tarsus more or less altered into ferruginous, with a correlated tendency to have the extent of the white or whitish markings on the hind tibia and tarsus reduced. All degrees of coloration from black and white to dusky ferruginous and ferruginous, to almost uniformly ferruginous hind tibia and tarsus occur among specimens from the same locality. Extensive collecting in various habitats and at altitudes of sea level to above timberline (about 6000 ft.) in the Northwest have failed to reveal any correlation of this tendency with a particular locality or habitat. As a rule, the smaller specimens are those that show this atypical coloration most frequently and most strongly.

*Specimens*: Many males and females from ALBERTA (Athabasin, Banff, Beaver Lodge, Cypress Hills, Edmonton, Gull Lake, Lake



Louise at 5600 ft., Wabamun, and Wetaskewin); ARIZONA (near Alpine at 8200 ft.); ARKANSAS (Polk Co.); BRITISH COLUMBIA (Clinton, Cultus Lake, Hazleton, Kokanee Mt. at 8000 ft., Likely, Nannaimo Biological Station, Revelstoke Mt. in the Santa Cruz Mts. at 6000 ft., and Robson at 1450 ft.); CALIFORNIA (Berkeley, Lake City, Redwood Corralitos, San Anselmo, and Taliac Lake at Tahoe); COLORADO (Georgetown, Green Mt. Falls, Veta Pass, and Westcliffe); CONNECTICUT (Lyme, Putnam, and Salisbury); ILLINOIS (Algonquin and Havana); MAINE (Bar Harbor, Casco, Echo Lake on Mt. Desert Island, and Lincoln Co.); MANITOBA (Aweme); MARYLAND (Bowie, Cabin John, Plummers Is., and Takoma Park); MASSACHUSETTS (Lexington and Needham); MICHIGAN (Chippewa Co., Midland Co., Missaukee Co., Ontonagon Co., and Roscommon Co.); MINNESOTA (Itasca State Park, Norman Co., Owatonna, St. Paul, and Two Harbors in Lake Co.); NEW BRUNSWICK (Fredericton); NEW HAMPSHIRE (summit of Mt. Washington, Pinkham Notch, and Randolph); NEW JERSEY (Moorestown); NEW MEXICO (Beulah, Pecos National Forest, and Tajique); NEW YORK (Artists Bridge in Essex Co., Bemus Point, Black Brook in Clinton Co., Canajoharie, Eastport, Hancock, Ithaca, McLean in Tompkins Co., Oneonta, Poughkeepsie, and Saranac Lake); NORTH CAROLINA (Pisgah Mt. at 4800 to 5300 ft., and at 5000 to 5749 ft.); NORTH WEST TERRITORIES (Cameron Bay on Great Slave Lake); NOVA SCOTIA (Baddeck); OHIO (Cantwell Cliffs); ONTARIO (Constance Bay, Jockvale, Kearney, Moosonee, Ottawa, Smoky Falls on the Mattagami River, Sudbury, and Toronto); OREGON (Cannon Beach, Corvallis, Diamond Lake in Douglas Co., Hood River, Meacham, 6 miles south of Parkdale, Seaside, and Soda Springs in Benton Co.); PENNSYLVANIA (Lehigh Gap and Spring Brook); QUEBEC (Aylmer, Brome, Cascapedia, Hemmingford, Hull, Kazubazua, Knowlton, Magog, Montreal, Mt. Lyall at 1500 ft., Stoneham, and Wright); RHODE ISLAND (Hopkington and Westerly); SASKATCHEWAN (Earl Grey, Redberry, and Waskesiu); SOUTH DAKOTA (Brookings and Spearfish); TENNESSEE (Gatlinburg and Knoxville); TEXAS (Trinity); VERMONT (Laurel Lake at Jacksonville, Plainfield, and summit of Mt. Mansfield); VIRGINIA (Chain Bridge near Rosslyn); WASHINGTON (Ashford, Mt. Rainier at 2700 ft., 2900 ft., 3800 ft., 4200 ft., 4700 ft., 5000 ft., and at 5300 ft., Northbend in King Co., Olympia at 5000 ft., Puyallup, Snoqualmie Pass, and Westport); and WEST VIRGINIA (Bolivar).

This species is the most abundant and widespread member of its genus in North America. It occurs from the Atlantic to the Pacific in the Hudsonian, Canadian, Transitional, and Upper Austral zones, being scarce in the Upper Austral. In the Hudsonian and Canadian zones it is common among ericaceous shrubs in woods and in the open, while in the Transitional Zone it is usually restricted to the undergrowth of moister woods. Adults are most common in June and July though individuals may be taken in almost any part of the season. On Mt. Rainier in 1940, we found that there was a peak of abundance at about 2900 ft. around July 10, a peak of abundance at about 4800 ft. around July 18, and a peak of abundance at about 5300 ft. around August 15. Noteworthy early and late dates of collection are April 6 at Berkeley, Calif.; May 2 at Kazubazua, Que.; May 4 at Cantwell Cliffs, Ohio;

September 2 at Wabamun, B. C.; September 20 at Bolivar, W. Va.; and October 27 at Cultus Lake, B. C.

Specimens before us have been reared from *Cladius isomerus* at Puyallup, Wash., by W. W. Baker, from a sawfly on *Betula populifolia* at Bar Harbor Me., and from *Blennocampa spiraeae* (no locality data). Procter (1938, Biol. Surv. Mt. Desert Region, 6:412) reports it as a parasite of *Croesus latitarsis*.

#### 5. *Polyblastus* (*Polyblastus*) *carbonarius* Gravenhorst

*Tryphon carbonarius* Gravenhorst, 1829. Ichneum. Europ. 2: 141. Type: ♂, Austria (? Breslau).

*Second tergite black; femora ferruginous; hind coxa black.*

Fore wing about 6.3 mm. long. Structurally similar to *P. pedalis* but slightly more robust and more strongly sculptured.

Colored as in typical *P. pedalis* except as follows: coxae, first trochanters, posterior corner of pronotum, and sometimes the tegula black; second trochanters more or less infuscate.

*Specimens:* ♀, Edmonton, Alta., June 15, 1937, F. O. Morrison (Townes); ♂, Mt. Washington, N. H., 6000 ft., July 11, 1946, M. Townes and J. Peck (Townes).

The species occurs also in northern Europe.

#### 6. *Polyblastus* (*Polyblastus*) *atrox*, new species

*Femora and coxae black; hind tibia palest at the base.*

Fore wing 6.2 mm. long; mesopleurum rather strongly and densely punctate; propodeum and first tergite strongly scabrorugose, with heavy strong carinae; costula moderately strong; petiolar area hexagonal, with a median longitudinal carina, about 1.5 as long as the combined basal area and areola; first tergite about 1.1 as long as broad, strongly arched towards its apex, its dorsal carinae reaching almost to the apex.

Black. Apical 0.68 of clypeus and mandible except at base and apex dark ferruginous; palpi brown; tegula black; bases of wings yellowish white; legs black, pale yellow as follows: fore and middle tibiae and tarsi, apices of fore and middle femora, basal 0.75 of hind tibia, tibial spurs, and basal 0.8 of first and basal 0.35 of second segments of hind tarsi; second trochanters dusky yellowish, partly infuscate.

*Type:* ♂, Norway Bay, Que., July 20, 1941, G. A. Hobbs (Ottawa).

#### 7. *Polyblastus* (*Polyblastus*) *fulvilinealis* Hall

*Polyblastus fulvilinealis* Hall, 1919. Psyche. 26: 155. Types: ♂, ♀, Riverside, Mass. and Auburndale, Mass. (Cambridge).

*Thorax largely ferruginous.*

Fore wing about 6.0 mm. long; mesopleurum rather finely punctate; propodeum and first tergite polished, the propodeum in part weakly punctate; propodeum with strong sharp carinae; costula strong; petiolar area subcircular, without a median longitudinal carina, about 1.0 as long as the combined basal area and areola; first tergite about 1.25 as long as broad, weakly arched above, its dorsal carinae weak and short, extending about 0.4 its length.

Black, the thorax with extensive ferruginous markings which may cover all of the thorax except for most of the mesoscutum and mesosternum or may be reduced to extensive stains on the mesopleurum and the propodeum. Clypeus, mandible except apex, palpi, under side of scape and pedicel, tegula, and hind corner of pronotum yellowish white; flagellum apically dusky ferruginous; legs ferruginous except as follows: front and middle trochanters and often their coxae more or less pale yellow; hind tibia, tibial spurs, and tarsus black with the basal 0.2 to 0.8 of the hind tibia whitish.

*Specimens*: Males and females from CONNECTICUT (Canterbury, Lebanon, and Ledyard); MAINE (Echo Lake and Mt. Cadillac, both on Mt. Desert Island); MARYLAND (Cabin John and Takoma Park); NEW HAMPSHIRE (Jaffrey, foot of Mt. Madison, and Randolph); NEW YORK (Farmingdale and Loch Muller in Essex Co.); NORTH CAROLINA (Pisgah Mt. at 4800 to 5300 ft.); PENNSYLVANIA (Harrisburg, Inglenook in Dauphin Co., Lehigh Gap, North Bloomfield, and Spring Brook); QUEBEC (Knowlton); RHODE ISLAND (Ashaway, Hopkington, and Westerly); and VERMONT (Laurel Lake at Jacksonville).

This species occurs in shaded rank shrubbery and herbage in the Transitional Zone of the East from Quebec to the District of Columbia and in the mountains to southern North Carolina. It is commonest from the middle of June through August, but has been caught as early as May 24 at North Bloomfield, Pa. and as late as October at Harrisburg, Pa.

#### 8. *Polyblastus (Polyblastus) wahlbergi* *rubescens*, new subspecies

*Polyblastus Wahlbergi sensu lato* Roman, 1931. Arkiv. för Zool. 23A, no. 6: 17. Recorded from Nova Scotia.

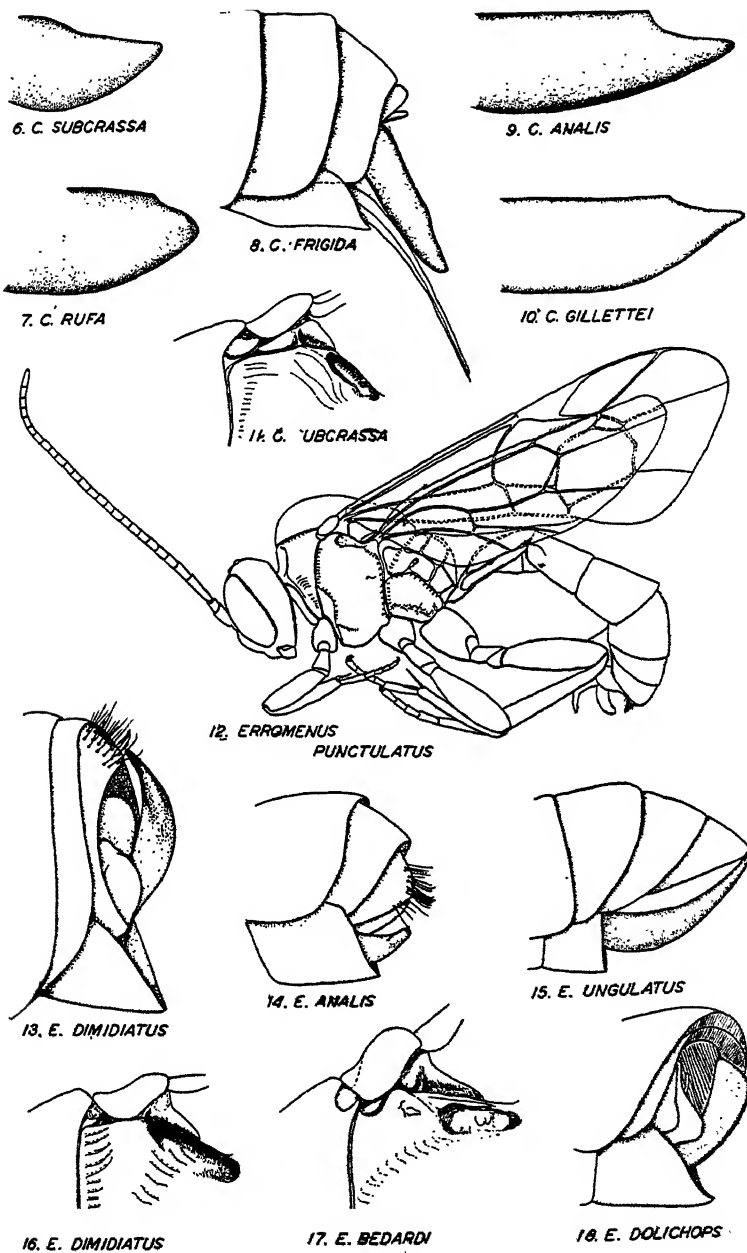
*Basal part of hind tibia whitish; hind femur mostly ferruginous; thorax black.*

Fore wing about 5.5 mm. long; mesopleurum rather sparsely and finely punctate; propodeum and petiole subpolished; propodeum with sharp carinae; costula weak or absent; petiolar area subcircular, without a median longitudinal carina, about 1.0 as long as the combined basal area and areola; first tergite about 1.45 as long as wide, weakly arched above; dorsal carinae of first tergite extending about 0.6 its length.

Black. Apical 0.6 of clypeus pale ferruginous or yellowish; mandible except apex, palpi, under side of scape and pedicel, tegula, posterior

#### EXPLANATION OF PLATE II

FIG. 6. *Ctenochira subcrassa*, ovipositor sheath. FIG. 7. *Ctenochira rufa*, ovipositor sheath. FIG. 8. *Ctenochira frigida*, ♀, end of abdomen. FIG. 9. *Ctenochira analis*, ovipositor sheath. FIG. 10. *Ctenochira gillettei*, ovipositor sheath. FIG. 11. *Ctenochira subcrassa*, subtegular ridge. FIG. 12. *Erromenus punctulatus*, ♀, side view. FIG. 13. *Erromenus dimidiatus* ♀, end of abdomen. FIG. 14. *Erromenus analis* ♀, end of abdomen. FIG. 15. *Erromenus unguulatus* ♀, end of abdomen. FIG. 16. *Erromenus dimidiatus*, subtegular ridge. FIG. 17. *Erromenus bedardi*, subtegular ridge. FIG. 18. *Erromenus dolichops* ♀, end of abdomen.



corner of pronotum, front and middle legs, apical margin of second and third tergites, and usually a median area extending from the base to the apex of the second and third tergites yellowish white; hind coxa and femur ferruginous, the apical part of the femur infuscate; hind trochanters yellowish white; hind tibia, tibial spurs, and tarsus black, the basal 0.3 to 0.8 of the hind tibia white to pale yellow.

The typical *P. wahlbergi* Holmgren 1855 of Europe differs in that it has the hind femur entirely castaneous, instead of ferruginous with the apical part of the femur castaneous or infuscate as in American specimens. The European *wahlbergi tener* Habermehl 1909 is colored as in *rubescens* but lacks the whitish marks on the tergites, and the European *wahlbergi wesmaeli* Holmgren 1855 is like *tener* but differs from *tener* and further from *rubescens* in having the hind coxa black.

*Type*: ♀, Laurentian Mountains, five to twenty miles north of Stoneham, Que., June 21, 1938, H. & M. Townes (Townes).

*Paratypes*: ♀, Pyziton, Clay Co., Ala., H. H. Smith (Washington). ♂, ♀, Edmonton, Alta., July 2 and 3, 1945, E. H. Strickland (Edmonton and Townes). ♀, Milton, Mass., June 11, 1899 (Cambridge). ♀, Randolph, N. H., July 4, 1946, M. Townes & J. Peck (Townes). ♂, Sixmile Creek, Ithaca, N. Y., June 22, 1937, P. P. Babiý (Townes). ♂, Ringwood, Tompkins Co., N. Y., May 17, 1936, H. Townes (Townes). ♀, Pisgah Mt., 5000 to 5749 ft., N. C., Sept. 5, 1939, H. & M. Townes (Townes). ♀, Spring Brook, Pa., June 27, 1945, H. Townes (Townes). ♀, collected with the type (Townes). ♀, Waskesiu, Sask., June 21, 1938, J. G. Rempel (Townes).

This species occurs in the undergrowth of woods.

### Subgenus **Cophenchus**, new subgenus

Figures 4 and 5

*Genotype*: *Polyblastus (Cophenchus) flexus*, new species.

Areolet present; hind tibia pale with the apex infuscate; costula weak, joining the petiolar area at its extreme base; ovipositor of even depth throughout, its dorsal valve suddenly rounded off at the apex to form a blunt point; shell of eggs whitish; mesopleurum rather sparsely and finely punctate; propodeum and petiole subpolished; propodeum with rather strong carinae; petiolar area hexagonal, without a median longitudinal carina, about 1.3 as long as the combined basal area and areola; first tergite about 1.3 as long as wide, moderately arched above.

The two known species of this subgenus are remarkably diverse in the shape and length of the ovipositor, shape of the clypeus and head, and place of attachment of the egg stalk to the egg.

#### KEY TO THE SPECIES OF THE SUBGENUS COPENCHUS

1. Apical margin of clypeus strongly convex; temple not unusually wide, in dorsal view much shorter than the eye; ovipositor straight; egg with stalk attached at one end (fig. 5).....1. *botrys*
- Apical margin of clypeus nearly straight; temple wide, in dorsal view much longer than the eye; ovipositor strongly downcurved; egg with stalk attached subapically (fig. 4).....2. *flexus*

1. *Polyblastus (Cophenchus) botrys*, new species

Figure 5

*Apical margin of clypeus strongly convex; ovipositor straight.*

Fore wing about 4.8 mm. long; clypeus about 2.5 as wide as long, its apical margin strongly convex; temple rounded off behind eye, from a dorsal view about 0.8 as long as eye; dorsal carinae of first tergite extending about 0.75 its length; ovipositor straight, about 1.1 as long as the abdomen; ovipositor sheath about 1.6 as long as the first tergite. The ovipositor is capable of carrying a great number of eggs, so that when loaded it looks like a miniature bunch of grapes. One specimen at hand has about fifty eggs on its ovipositor, making a bunch larger than the insect's abdomen. Egg normal for the tribe, with the stalk attached at its smaller end (fig. 5).

Black. Clypeus, gastrocoeli, and apical margins of first three tergites light ferruginous; mandible except at its apex, palpi, pedicel, scape, underside of basal part of flagellum, tegula, and posterior corner of pronotum pale yellow. Legs pale yellow with the hind femur except apically pale ferruginous, the apical 0.2 of the hind tibia fuscous, and the hind tarsus fuscous with the basal part of each segment more or less pale.

*Type:* ♀, Laurentian Mountains, five to twenty miles north of Stoneham, Que., June 21, 1938, H. & M. Townes (Townes).

*Paratypes:* ♀, Aweme, Man., July 9, 1924 R. D. Bird (Ottawa). ♀, South Hadley, Mass., May 25, 1936, M. C. Townes (Townes). ♂, Midland Co., Mich., May 12, 1941, R. R. Dreisbach (Townes). ♀, Midland Co., Mich., June 1, 1940, R. R. Dreisbach (Townes). ♂, Saginaw Co., Mich., June 1, 1941, R. R. Dreisbach (Townes). ♀, Randolph, N. H., July 5, 1946, M. Townes & J. Peck (Townes).

2. *Polyblastus (Cophenchus) flexus*, new species

Figure 4

*Apical margin of clypeus nearly straight; ovipositor decurved.*

Fore wing about 4.7 mm. long; clypeus about 3.4 as wide as long, its apical margin almost straight; temple slightly expanded behind the eye, from a dorsal view about 1.3 as long as the eye; dorsal carinae of first tergite extending about 0.33 its length; ovipositor strongly down-curved, making almost a semicircle, measured along the curve about 0.4 as long as the abdomen; ovipositor sheath about 0.26 as long as the first tergite; egg with its stalk attached about 0.3 from one end, thus differing from the eggs of all other Tryphoninae known to us (fig. 4).

Black. Basal half of mandible, palpi, posterior corner of pronotum, tegula, and wing bases pale yellow; apical half of mandible red-brown shading to black at the tip; clypeus, underside of scape and pedicel, and legs light ferruginous, the hind tibia narrowly and segments of the hind tarsus broadly infuscate apically; first tergite blackish brown, the remaining tergites reddish brown to dark brown, margined with paler, or the apical ones entirely ferruginous.

*Type:* ♀, Edmonton, Alta., June 19, 1937 (Townes).

*Paratypes*: ♂, Likely, B. C., July 2, 1938, G. S. Walley (Ottawa). ♀, Laniel, Que., June 11, 1942, O. Peck (Ottawa). 2 ♀, on cherry, Edmonton, Alta., June 8, 1946, Wm. R. M. Mason (Mason, Townes). ♀, Edmonton, Alta., June 29, 1946, Wm. R. M. Mason (Mason).

### Subgenus *Labroctonus*

*Labroctonus* Foerster, 1868. Verh. Naturh. Ver. Preuss. Rheinlande. 25: 195.

Type: *Tryphon articulatus* Cresson. Included by Davis 1897.

*Nemioblastus* Thomson, 1883. Opusc. Ent. 9: 901. Type: *Polyblastus* (*Nemioblastus*) *albicoxa* Thomson. Designated by Viereck 1914.

Clypeus unusually wide; areolet absent; costula present, joining the combined areola and basal area about 0.33 from its apex; ovipositor tapered to a sharp point; shell of egg smoky to black.

The American species of *Labroctonus* are divisible into four groups on minor differences in the pectinations of the tarsal claws, correlated with a very few other characters. The Palaearctic species are not discussed because only a little material with doubtful determinations is available.

1. *Dorsalis* group. Subtegular ridge rounded (fig. 3); apical edge of pecten of tarsal claws curved, the apical pecten teeth appearing shorter and the pecten not reaching the apical tooth of the claw, so that there is a distinct gap between the pecten and the claw apex. The Nearctic *dorsalis* and *jugatus* are included.

2. *Alatus* group. Subtegular ridge produced as a small sharp upright lamina (fig. 2); apical edge of pecten of tarsal claws curved, the apical pecten teeth appearing shorter and the pecten not reaching the apical tooth of the claw, so that there is a distinct gap between the pecten and the claw apex. The Nearctic *alatus*, *bimacula*, and *rutilus* are included.

3. *Articulatus* group. Subtegular ridge rounded; pecten of tarsal claws with a straight apical edge, extending nearly or quite to the apical tooth of the claw. The Nearctic *productus*, *gloriosus*, *galaphilus*, *articulatus*, *peckae*, and *buccatus*, and the Holarctic *stenocentrus* are included.

4. *Expletus* group. Similar to the *articulatus* group but the tarsal claws relatively long and the body build stouter and ovipositor sheath shorter (3.8= as long as broad) than in other groups (ovipositor sheath 4.5 as long as broad). The Nearctic *expletus* is the only species included.

#### KEY TO THE AMERICAN SPECIES OF THE SUBGENUS LABROCTONUS

1. Mesopleurum just below the tegula produced upwards and outwards as a thin sharp-edged flange, almost reaching the lower edge of the tegula (fig. 2); abdomen beyond the first tergite largely ferruginous. . . . . 2  
     Mesopleurum just below the tegula forming a rounded longitudinal ridge, not produced upwards (fig. 3). . . . . 4
2. Thorax ferruginous. . . . . 4. *rutilus*  
     Thorax black. . . . . 3
3. Lateral margin of posterior part of mesoscutum produced upwards as a flange that is about 0.7 as wide as the tegula; upper portion of vertical ridge on mesonotum that is just behind the base of the fore wing produced as a lobe that is about 1.1 as high as wide; cheek black. . . . . 5. *alatus*  
     Lateral margin of posterior part of mesoscutum produced upwards as a flange that is about 0.3 as wide as the tegula; upper portion of vertical ridge of mesonotum that is just behind the base of the fore wing produced as a lobe that is about 0.5 as high as wide; cheek usually white. . . . . 3. *bimacula*

4. First and second tergites largely or entirely ferruginous; fore wing about 7.3 mm. long; ovipositor sheath about 3.8 as long as wide. . . . .13. **expletus**  
First and second tergites black, with whitish, ochraceous, or dark brown apical margins and sometimes the second tergite with a median pale area; fore wing about 4.0 to 6.3 mm. long; ovipositor sheath about 4.5 as long as wide. . . . .5
5. Pronotum largely or entirely ferruginous. . . . .6  
Pronotum black except for its whitish postero-lateral corner. . . . .7
6. Scutellum ferruginous; propodeum black; pectination of tarsal claws dense, the apical pecten tooth separated from the apical point of the claw by about its diameter. . . . .7. **gloriosus**  
Scutellum black; propodeum more or less ferruginous; pectination of tarsal claws moderately dense, the apical pecten tooth separated from apical point of the claw by several times its diameter. . . . .2. **jugatus**
7. Apical pecten teeth of tarsal claws much shorter than the basal ones so that the edge of the pectination has a sharp inward curve; pecten teeth separated by about 1.2 their diameter in the male and by about 1.5 their diameter in the female; lower half of the mesopleurum with weak, sparse punctures; second, third, and sometimes the fourth tergites with a median pale area or with the apical and basal pale margins strongly widened medially. . . . .1. **dorsalis**  
Apical pecten teeth of tarsal claws as long as the basal ones so that the edge of the pectination is straight to the apex; pecten teeth separated by about 0.8 their diameter in the male and by about 1.0 their diameter in the female; lower part of mesopleurum with somewhat stronger and denser punctures; tergites without a median pale area, the apical pale margin uniformly narrow. . . . .8
8. Hind coxa dark castaneous to black, its extreme apex often more or less yellowish. . . . .9  
Hind coxa ferruginous, sometimes more or less unevenly infusate. . . . .11
9. Hind femur ferruginous. . . . .9. **stenocentrus**  
Hind femur castaneous to black. . . . .10
10. Tergites without a conspicuous pale hind margin; hind tibia not infusate basally. . . . .10. **peckae**  
Tergites with a conspicuous pale hind margin; hind tibia weakly infusate basally. . . . .11. **articulatus**
11. Scape black, indistinctly dusky ferruginous in front; front and middle coxae ferruginous; as seen from above, the temple about 0.85 to 1.1 as long as the eye. . . . .12. **buccatus**  
Scape pale yellow in front; front and middle coxae white to yellow; as seen from above, the temple about 0.60 to 0.80 as long as the eye. . . . .12
12. Cheek black; combined areola and basal area longer than the petiolar area; upper bulla in second recurrent vein separated usually by less than half its length from the cubital vein. . . . .6. **productus**  
Cheek usually white; combined areola and basal area shorter than the petiolar area; upper bulla in second recurrent vein separated usually by more than half its length from the cubital vein. . . . .8. **galaphilus**

### 1. *Polyblastus (Labroctonus) dorsalis*

Provancher, new combination

Figure 3

*Tryphon dorsalis* Provancher, 1879. Nat. Canad. 11: 253; Faune, p. 411. Type: ♀, Quebec (Quebec).

*Pecten of tarsal claws shorter apically, not reaching the apical tooth of the claw; pronotum black; tergites blackish marked with stramineous.*

Fore wing about 4.4 mm. long; as seen from above, the temple about 0.70 as long as the eye; lower half of mesopleurum with sparse, small or very small punctures; mesopleurum just below the tegula with a rounded longitudinal ridge; pectination of tarsal claws moderately dense, the apical teeth not projecting nearly as far as the subbasal ones



and the pecten not extending the full length of the claw so that there is a conspicuous gap between the pecten and the apical tooth of the claw; body build medium.

**Black.** Clypeus, usually the cheek, mandible except its apex, palpi, hind corner of pronotum, tegula, wing bases, coxae, trochanters, and all except apical  $0.15\pm$  of hind tibia whitish yellow; scape and pedicel light to dark stramineous; extreme apex of first tergite and usually of the fifth and following tergites light to dark stramineous; second to fourth tergites some shade of stramineous with a large dark brown triangle on each side, the triangle apices pointing inwards and often meeting, or in many specimens the dark brown color on the second to fourth tergites is so extensive that only the basal and apical margins, widened medially, are stramineous. Front and middle legs beyond the trochanters ferruginous; hind femur ferruginous or sometimes pale castaneous; apical  $0.15\pm$  of hind tibia fuscous, its tibial spurs stramineous; hind tarsus fuscous, the segments, especially the first segment, pale basally.

*Specimens:* Males and females from ALBERTA (Edmonton and Slave Lake); BRITISH COLUMBIA (Canim Lake); CALIFORNIA (Felton in the Santa Cruz Mts. at 300 to 500 ft., Redwood Corralitos in the Santa Cruz Mts., and Siskiyou Co.); COLORADO; CONNECTICUT (East River); MAINE (Orono); MANITOBA (Aweme); NEW HAMPSHIRE (Randolph); NEW YORK (Bemus Point, Cranberry Lake, Ithaca, Oneonta, Ringwood in Tompkins Co., and Saranac Lake); NOVA SCOTIA (Baddeck); ONTARIO (Jockvale); QUEBEC (Aylmer, Burbridge, Gracefield, and Knowlton); RHODE ISLAND (Westerly); SASKATCHEWAN (Waskesiu); and WASHINGTON (Westport).

This species occurs in rank shaded herbage and shrubbery in the Canadian and Transitional zones from the Atlantic to the Pacific. In the East, it has not yet been taken south of New York. Adults have been collected as early as May 13 in the Santa Cruz Mts. of California and May 17 in Tompkins Co., N. Y. and as late as Sept. 3 at East River, Conn. The East River specimen was reared by C. R. Ely and bears the label "*Populus tremiloides* edge turner, collected July 13 to Aug. 2., emerged Sept. 3, 1912." A specimen from Orono, Me. was reared July 12, 1913 from *Pristiphora sycophanta*.

## 2. *Polyblastus* (*Labroctonus*) *jugatus*, new species

*Pronotum largely ferruginous; scutellum black; second tergite black, margined with dusky ferruginous.*

Fore wing 5.3 mm. long; as seen from above, temple 0.64 as long as the eye; lower half of mesopleurum with weak and rather sparse punctures; mesopleurum just below tegula with a rounded longitudinal ridge; pectination of tarsal claws long and rather dense, the apical teeth not projecting as far as the subbasal ones and the apical pecten tooth separated from the apical tooth of the claw so that there is a conspicuous gap between the pecten and the claw tip; body build medium.

**Black.** Clypeus, mandible except apex, palpi, hind corner of pronotum, tegula, wing bases, and all but the apical 0.18 of hind tibia

whitish yellow; scape and pedicel dusky ferruginous beneath; propleurum castaneous, margined with dusky ferruginous; pronotum dark ferruginous, its dorso-anterior part with an ill-defined castaneous area; mesepimeron dark ferruginous; apical 0.5 of propodeum dark ferruginous, the ferruginous part not sharply defined; front and middle legs and hind legs basad of tibiae ferruginous, their trochanters slightly paler; apical 0.18 of hind tibia fuscous, its tibial spurs whitish; hind tarsus fuscous, the segments pale basally; apical margins of first three tergites and extreme bases of second and third tergites dusky ferruginous, the fourth and following tergites very narrowly margined with ferruginous.

*Type*: ♂, Pinkham Notch, N. H., June 25, 1938, H. & M. Townes (Townes).

### 3. *Polyblastus (Labroctonus) bimacula*, new species

*Abdomen largely ferruginous; thorax black; lateral margin of posterior part of mesoscutum not produced as a conspicuous flange.*

Fore wing 5.6 mm. long; as seen from above, the temple about 0.65 as long as the eye; lower half of mesopleurum with well separated punctures; mesopleurum just below the tegula produced upwards as a thin sharp-edged flange whose upper margin almost reaches the tegula (as in *alatus*, fig. 2); pectination of tarsal claws dense, the apical teeth not projecting as far as the subbasal ones and the pecten not quite reaching the apical tooth of the claw, so that there is a conspicuous gap between the pecten and the apical tooth of the claw; body build medium.

Black with the abdomen beyond the first tergite mostly ferruginous. Clypeus, mandible except its apex, usually the cheek, palpi, under side of scape, hind corner of pronotum, tegula, wing bases, front and middle coxae, trochanters, and all but the apical  $0.2\pm$  of hind tibia whitish yellow. The fore and middle coxae are often more or less ferruginous, especially towards their bases, and the base of the hind tibia as often ferruginous or somewhat infuscate. Pedicel and upper side of scape dusky ferruginous to pale yellow; front and middle legs beyond the trochanters and hind coxa and femur ferruginous; apical  $0.2\pm$  of hind tibia fuscous, its tibial spurs whitish; hind tarsus fuscous, the bases of the segments paler; median part of apical margin of first tergite ferruginous; second and following tergites entirely ferruginous except that there are usually a pair of ill-defined brownish triangles with inward pointed apices on each of the second and third tergites and that the abdomen may be darkened apically and laterally, especially in males.

*Paratypes*: ♂, Bilby, Alta., June 14, 1924, G. Salt (Edmonton). ♂, Bilby, Alta., July 4, 1924, O. Bryant (Edmonton). 2 ♀, Wabamun, Alta., July 4 and 5, 1940, E. H. Strickland (Edmonton). ♀, Cultus Lake, B. C., Oct. 22, 1938, J. K. Jacobs (Ottawa). 2 ♂, Casco, Me., Aug. 1 to 2 and Aug. 11, 1944, J. C. Bradley (Ithaca). ♂, Takoma Park, Md., Aug. 16, 1942, H. & M. Townes (Townes). ♀, Chester, Mass., Aug. 5, 1911 (Cambridge). ♀, Makinac Island, Mich., C. H. Kennedy (Columbus). 2 ♀, Randolph, N. H., July 4 and 7, 1946, M. Townes and J. Peck (Townes). ♂, Oneonta, N. Y., Aug. 31, 1935

H. Townes (Townes). 2 ♀, Pisgah Mt. at 5000 to 5749 ft., N. C., Sept. 5, 1939, H. & M. Townes (Townes). ♀, Stoneham, Que., June 21, 1938, H. & M. Townes (Townes). ♀, Westerly, R. I., June 12, 1937, H. & M. Townes (Townes). ♀, Waskesiu Lake, Sask., July 31, 1939, A. B. Brooks (Ottawa). ♀, Falls Church, Va., June 4, N. Banks (Cambridge). 2 ♂, 8 ♀, Ashford, Wash., July 10, 1940, July 27, 1940, Aug. 18, 1940, and Aug. 19, 1940, H. & M. Townes (Townes). ♀, Barnes State Park, Wash., Aug. 12, 1940, H. & M. Townes (Townes). ♀, Elbe, Wash., July 25, 1940, H. & M. Townes (Townes). 4 ♂, 4 ♀, Mt. Rainier at 2700 ft., 2900 ft., 4000 ft., and 4200 ft., collected in 1940 on July 7, 8, and 15, and Aug. 13, and 14, H. & M. Townes (Townes). ♂, no locality, Aug. 1, 1894 (Ottawa). ♀, no data (Ithaca).

This species occurs in the rank vegetation of moist woods in the Transitional and Canadian zones from the Atlantic to the Pacific. Adults have been taken from June 12 at Westerly, R. I. to October 22 at Cultus Lake, B. C.

#### 4. *Polyblastus (Labroctonus) rutilus*, new species

*Thorax entirely ferruginous.*

Fore wing about 5.7 mm. long; as seen from above, the temple about 0.77 as long as the eye; lower half of mesopleurum with well separated punctures; mesopleurum just beneath the tegula produced upwards as a thin sharp-edged flange whose upper margin almost reaches the tegula (as in *P. alatus*, fig. 2); pectination of tarsal claws dense, the apical teeth not projecting as far as the subbasal ones and the pecten not quite reaching the apical tooth of the claw, so that there is a conspicuous gap between the pecten and the apical tooth of the claw; body build medium.

Light ferruginous with the head black. Clypeus, mouth parts, hind corner of pronotum, tegula, and trochanters yellow; face ferruginous, somewhat infuscate laterally; region around base of mandible stained with ferruginous; scape and pedicel yellowish in front; flagellum brown; tibiae, tarsi, and tibial spurs stramineous, the hind tibia lightly infuscate on its apical 0.2= and the hind tarsal segments infuscate with their bases pale; ovipositor sheath light brown.

*Type:* ♀ (lacks flagella), Cazadero, Calif., May 12, 1918, E. P. VanDuzee (San Francisco).

*Paratypes:* ♂ (abdomen and most of head and thorax missing), Mill Valley, Marin Co., Calif., Mar. 28, 1926 (San Francisco). ♀ (lacks abdomen), Ross, Calif., Apr. 28, 1918, J. C. Bradley (Ithaca).

#### 5. *Polyblastus (Labroctonus) alatus*, new species

Figure 2

*Lateral margin of hind part of mesoscutum produced upwards as a flange that is about 0.8 as wide as the tegula.*

Fore wing 5.5 mm. long; as seen from above, the temple about 0.73 as long as the eye; lower half of mesopleurum with well separated punctures; mesopleurum just beneath the tegula produced upwards as a thin sharp-edged flange whose upper margin almost reaches the tegula

(fig. 2); lateral margin of hind part of mesoscutum produced as an up-curved thin flange that is about 0.8 as wide as the tegula (this is present in other members of the genus but in these it is not more than about 0.3 as wide as the tegula and is more like a carina than a flange); pectination of tarsal claws dense, the apical teeth not projecting as far as the subbasal ones and the pecten not quite reaching the apical tooth of the claw, so that there is a conspicuous gap between the pecten and the apical tooth of the claw; body build medium.

Colored as in *bimacula*, but the cheek always black.

*Type*: ♀, on Northwest Branch at University Lane bridge, Takoma Park, Md., June 14, 1942, H., M., & G. Townes (Townes).

*Paratypes*: 2 ♂, Georgetown, D. C., H. H. Smith (Washington). 2 ♂, ♀, Cabin John, Md., collected June 1912, June 1917, and Sept. 1915 by R. M. Fouts (Washington). ♀, Cabin John, Md., June 14, S. A. Rohwer (Washington). ♀, Cabin John Bridge, Md., R. M. Fouts (Washington). ♀, Cabin John Bridge, Md., (Washington). ♂, ♀, on Northwest Branch at University Lane bridge, Takoma Park, Md., June 7 and June 21, 1942, H. & M. Townes (Townes). ♀, Takoma Park, Md., Sept. 12, 1942, H. & M. Townes (Townes). ♂, 3 ♀, Poughkeepsie, N. Y., collected July 15, July 23, July 24, and Aug. 2, 1936 by H. Townes (Townes). ♂, Mt. Holly Springs, Pa., July 7, 1918, R. M. Fouts (Washington). ♀, Mt. Holly Springs, Pa., Sept. 1, 1918, R. M. Fouts (Washington). 2 ♀, Falls Church, Va., June 28, 1918, R. A. Cushman (Washington). ♀, Great Falls, Va., July 21 (Cambridge). 2 ♂, 4 ♀, Rosslyn, Va., H. H. Smith (Washington).

This species occurs in the rank vegetation of moist woods in the southern part of the Transitional Zone from New York to Virginia. Adults have been taken at Takoma Park, Md. from June 7 to September 12, most of them in June and July.

## 6. *Polyblastus (Labroctonus) productus*, new species

*Edge of claw pecten straight; thorax black; scape yellow in front; cheek black; combined areola and basal area longer than the petiolar area.*

Fore wing about 6.0 mm. long; as seen from above, the temple about 0.67 as long as the eye; lower half of mesopleurum with well separated punctures; mesopleurum just below the tegula with a rounded longitudinal ridge; pectination of tarsal claws even, long, and dense, with no gap between the last pecten tooth and the apical tooth of the claw; body build rather slender, the propodeum slightly longer and flatter than usual, with the combined areola and basal area usually longer than the petiolar area.

Black. Clypeus, mandible except its apex, palpi, under side of scape and pedicel, posterior corner of pronotum, tegula, wing bases, trochanters, front and middle coxae, and all except the apical 0.18= and often the basal 0.1= of the hind tibia whitish yellow; front and middle legs beyond the trochanters and hind femur ferruginous or sometimes castaneous, in which case it is darkest above; hind coxa ferruginous, usually infusate dorsally; apical 0.18= of hind tibia infusate, its tibial spurs whitish; hind tarsus blackish, the segments paler at the base,

the first segment most broadly so; basal  $0.1\pm$  of the hind tibia sometimes distinctly infusate; apical margins of abdominal tergites and basal margins of second and third tergites ochraceous.

*Type*: ♀, Round Pass, 4000 ft., Mt. Rainier, Wash., Aug. 14, 1940, H. & M. Townes (Townes).

*Paratypes*: 5 ♀, collected with the type, and ♀, Lake George, 4200 ft., Mt. Rainier, Wash., July 15, 1940, H. & M. Townes (Townes).

In addition to the paratypes there is a male collected at Fish Creek, 2900 ft., Mt. Rainier, Wash., August 14, 1940 by H. & M. Townes (Townes) which is slightly larger and stouter than the type and paratypes and has the hind femur almost entirely castaneous.

All specimens were taken in Canadian coniferous woods among shoulder-high *Vaccinium* and other ericaceous shrubs. There appears to be a peak of abundance around the middle of August as, except for a single specimen, none were seen in visits on July 7, 12, 15, and 28, 1940 to the same areas which yielded the specimens listed above.

### 7. *Polyblastus* (*Labroctonus*) *gloriosus*

Davis, new combination

*Phaestus gloriosus* Davis, 1898. Trans. Amer. Ent. Soc. 24: 292. Type: ♀, Wash. (Philadelphia).

*Thorax largely ferruginous; scutellum ferruginous; second tergite black, marked with whitish.*

Fore wing about 5.0 mm. long; as seen from above, the temple about 0.70 as long as the eye; lower half of mesopleurum with well separated punctures; mesopleurum just below the tegula with a rounded longitudinal ridge; pectination of tarsal claws even, long, and dense, with no gap between the last pecten tooth and the apical tooth of the claw; body build medium.

Black, the thorax partly ferruginous. Clypeus, malar space, mandible except its apex, palpi, under side of scape and pedicel, posterior corner of pronotum, tegula, wing bases, coxae, trochanters, and all except apical  $0.15\pm$  of hind tibia yellowish white; upper side of scape brownish ferruginous to yellowish; propleurum, mesoscutum except often for a median dark stripe, scutellum, and anterior part of mesopleurum ferruginous; front and middle legs beyond trochanters and hind femur ferruginous, the femur somewhat infusate at the apex; apical  $0.15\pm$  of hind tibia fuscous, the hind tibial spurs whitish; hind tarsus fuscous, pale at the bases of the segments, more broadly so at the base of the first segment; basal  $0.1\pm$  of hind tibia often infusate; tergites with a stramineous to buff apical margin, the second to fourth tergites with a basal margin of the same color. The basal and apical pale margins of the second to fourth tergites are widened medially, often, especially in females, widened to such an extent that the pale of the basal and apical margins meet to form a median longitudinal pale band and the black color is reduced to two lateral areas.

*Specimens*: 4 ♂, Crescent City, Calif., Aug. 2 and 3, 1940, H. & M. Townes (Townes). ♂, ♀, Cannon Beach, Oreg., Aug. 11, 1940, H. & M. Townes (Townes). ♀, Warrenton, Oreg., Aug. 8, 1940, H. & M. Townes (Townes). ♀, Casapedia, Que., Aug. 15, 1933, W. J.

Brown (Ottawa). 2 ♂, Ashford, Wash., Aug. 18, 1940, H. & M. Townes (Townes). 2 ♂, ♀, Westport, Wash., July 17, 1940, H. & M. Townes (Washington and Townes).

This species occurs in rank herbage and shrubbery.

#### 8. *Polyblastus (Labroctonus) galaphilus*, new species

*Edge of claw pecten straight; thorax black; scape yellow in front; cheek usually white; combined basal area and areola shorter than the petiolar area.*

Fore wing about 5.5 mm. long; as seen from above, the temple about 0.62 as long as the eye in the male and about 0.70 as long as the eye in the female; lower half of mesopleurum with well separated punctures; mesopleurum just below the tegula with a rounded longitudinal ridge; pectination of tarsal claws even, long, and dense, with no gap between the last pecten tooth and the apical tooth of the claw; body build medium; upper bulla of second recurrent vein separated from cubitus usually by more than half its length (this bulla in other species is usually slightly closer to the cubital vein).

Black. Clypeus, usually the cheek, mandible except its apex, palpi, under side of scape and pedicel, trochanters, fore and middle coxae, hind corner of pronotum, tegula, wing bases, hind tibia except for its infusate base and apex, apical margin of tergites and basal margin of second and third tergites whitish yellow; front and middle legs beyond trochanters, hind coxa, and hind femur ferruginous; basal  $0.1 \pm$  of hind tibia weakly infusate, the apical  $0.18 \pm$  strongly infusate; hind tibial spurs whitish; hind tarsus fuscous, the first segment pale at the base and the rest of the segments pale at the extreme base.

*Type:* ♀, collected in woodland west just across highway from the railway station at Ashford, Wash., July 26, 1940, H. & M. Townes (Townes).

*Paratypes:* ♀, Banff at 4600 ft., Alta., Aug. 16, 1924 G. Salt (Washington). ♂, Edmonton, Alta., June 5, 1924, Owen Bryant (Townes). ♀, Northeast Harbor, Maine, Aug. 10, 1911, C. W. Johnson (Washington). ♂, Randolph, N. H., July 4, 1946, M. Townes and J. Peck (Townes). ♂, Cranberry Lake, N. Y., June 21, 1925 (Washington). ♂, ♀, Meacham, Oreg., Aug. 20, 1940, H. & M. Townes (Townes). ♀, Hull, Que., May 31, 1903 (Ottawa). ♀, Waskesiu, Sask., June 25, 1938, J. G. Rempel (Townes). ♀, collected with the type (Townes). 2 ♀, Ashford, Wash., Aug. 18, 1940, H. & M. Townes (Townes). ♀, Elbe, Wash., July 25, 1940, H. & M. Townes (Townes).

This species occurs in the rank undergrowth of moist woods in the Transitional and Canadian zones from the Atlantic to the Pacific. It has not been taken south of New York in the East nor of Oregon in the West. Adults have been taken from May 31 to August 20.

#### 9. *Polyblastus (Labroctonus) stenocentrus*

Holmgren, new combination

*Polyblastus stenocentrus* Holmgren, 1855. Svenska Vet.-Akad. Handl. 1: 215.

*Types:* ♂, ♀, Sweden (? Stockholm).

*Hind coxa blackish; hind femur ferruginous.*

Fore wing about 6.2 mm. long; temple swollen, as seen from above about 0.90 as long as the eye; lower half of mesopleurum with well sepa-

rated punctures; mesopleurum just below the tegula with a rounded longitudinal ridge; pectination of tarsal claws even, long, and dense, the pecten not extending quite the full length of the claw so that there is a very small gap between its end and the apical tooth of the claw; body build medium.

Black. Clypeus, mandible except apex, palpi, tegula, and wing bases pale yellowish; scape dusky ferruginous below; legs ferruginous, the trochanters paler; hind coxa black; front and middle coxae blackish basally; hind tibia pale ferruginous, the basal  $0.12\pm$  slightly infusate and the apical  $0.2\pm$  infusate; hind tibial spurs pale ferruginous; hind tarsus blackish, the first segment pale basally and the rest of the segments pale at the extreme base; apical margin of tergites and extreme basal margin of second and third tergites buff.

*Specimens:* ♂, 2 ♀, Mt. McKinley National Park, Alaska, 1932, F. W. Morand (Washington and Townes).

These specimens have been compared with a European female determined by Pfankuch. In view of the difficulty of distinguishing species in this group, it is not certain that the European and American specimens really represent the same species nor that Pfankuch's determination is correct. However, we find no valid grounds for describing the American specimens as representing a new species. In the Palaearctic region, *stenocentrus* is reported from northern Europe and Kamchatka.

#### 10. *Polyblastus (Labroctonus) peckae*, new species

*Hind femur black; tergites without a conspicuous pale hind margin.*

Type female: Fore wing 6.7 mm. long; temples swollen, as seen from above 0.93 as long as the eye; lower half of mesopleurum with well separated punctures; mesopleurum just below the tegula with a rounded longitudinal ridge; pectination of tarsal claws even, long, and dense, with no gap between the end of the pecten and the apical tooth of the claw; body build medium.

Black. Clypeus, basal 0.6 of mandible, posterior corner of pronotum, and tegula yellow; apical part of mandible red-brown shading to dark brown at the tip; palpi stramineous; under side of scape with a reddish stain; legs light red, the apical half of the fore and middle coxae, trochanters except the hind ones posteriorly, and a small spot on the apex of the front femur yellow; hind coxa and femur black, the femur reddish at the base; hind tibia stramineous with the apical 0.25 blackish; hind tarsal segments blackish, pale at the base; ovipositor sheath dark brown.

*Type:* ♀, Randolph, N. H., July 2, 1946, M. Townes and J. Peck (Townes).

#### 11. *Polyblastus (Labroctonus) articulatus* Cresson, new combination

*Tryphon articulatus* Cresson, 1868. Trans. Amer. Ent. Soc. 2: 110. Type: ♀, Hudson Bay Territory (Philadelphia).

*Hind femur castaneous; tergites margined with whitish.*

Fore wing about 5.3 mm. long; temple rather swollen, as seen from above about 0.90 as long as the eye; lower half of mesopleurum with well separated punctures; mesopleurum just below tegula with a rounded longitudinal ridge; pectination of tarsal claws even, long, and dense,

with no gap between the end of the pecten and the apical tooth of the claw; body build medium.

Colored as is *Polyblastus stenocentrus* except that the hind femur is castaneous.

*Specimens:* ♀, Lake Louise, Alta., July 29, 1938, G. S. Walley (Townes). ♂, Churchill, Man., July 24, 1937, W. J. Brown (Ottawa). ♀, Churchill, Man., July 31, 1937, W. J. Brown (Ottawa). ♀, Churchill, Man., Aug. 2 to 9, 1937, D. G. Denning (St. Paul).

## 12. *Polyblastus (Labroctonus) buccatus*, new species

*Scape black, indistinctly ferruginous in front; hind coxa mostly or entirely ferruginous; thorax black.*

Fore wing about 5.5 mm. long; temple strongly swollen, as seen from above about 0.87 as long as the eye in the male and about 1.1 as long as the eye in the female; lower half of mesopleurum with well separated punctures; mesopleurum just below tegula with a rounded longitudinal ridge; pectination of tarsal claws even, long, and dense, with no gap between the last pecten tooth and the apical tooth of the tarsal claw; body build slightly stouter than usual.

Black. Clypeus, posterior corner of pronotum, tegula, and wing bases whitish yellow; mandible whitish yellow, its apical part pale ferruginous tipped with castaneous; palpi pale ferruginous; under side of scape dusky ferruginous; legs ferruginous, the hind tibia with the apical  $0.18\pm$  infuscate and sometimes slightly infuscate towards the base; hind tarsus fuscous, dusky ferruginous at the bases of the segments. The hind coxa of the male is ferruginous but somewhat infuscate on its basal two-thirds. In the female the hind coxa is uniformly ferruginous. Apical margins of tergites brown, the margins palest and broadest on the second and third segments.

*Type:* ♀, Paradise Valley, where highway crosses Edith Creek at 4700 ft., Mt. Rainier, Wash., July 11, 1940, H. & M. Townes (Townes).

*Paratypes:* 2 ♂, ♀, collected with the type (Townes). ♂, Mt. Rainier at 5000 ft., Wash., July 9, 1940, H. & M. Townes (Townes). ♀, Mt. Rainier at 5300 ft., Wash., Aug. 15, 1940, H. & M. Townes (Townes).

The above specimens were all collected at timberline where scattered groups of conifers are interspersed with mountain meadows.

## 13. *Polyblastus (Labroctonus) expletus*, new species

*Second tergite ferruginous; thorax black and ferruginous.*

Fore wing about 7.3 mm. long; as seen from above, the temple about 0.63 as long as the eye in the male and about 0.92 as long as the eye in the female; lower part of mesopleurum with moderately dense punctures (usually distinctly more strongly and closely punctate than in other members of the subgenus); mesopleurum just below the tegula with a rounded longitudinal ridge; pectination of tarsal claws even, moderately long, and dense, with no gap between the last pecten tooth and the apical tooth of the claw; ovipositor sheath about 3.8 as long as broad (about 4.5 as long as broad in all other members of the subgenus); body build more robust than in other members of the subgenus.



Black, the thorax and abdomen partly ferruginous. Clypeus, mandible except apex, palpi, tegula, and wing bases and sometimes the cheek pale yellowish; sometimes the face marked medially with yellow or ferruginous; scape and pedicel more or less ferruginous in front; thorax black, with more or less extensive ferruginous areas covering some or all of the pronotum, scutellum, and propodeum. Sometimes all the thorax except the mesosternum and lower three-fourths of the mesopleurum are ferruginous. Legs ferruginous, the tibiae somewhat paler; apical  $0.1\pm$  of hind tibia infusate; hind tarsus infusate, darkest towards the apices of the segments; abdomen ferruginous, the fourth and following tergites black; third tergite black laterally and sometimes entirely black except for its base; first tergite usually with ill-defined dark markings, especially towards its base.

*Type*: ♀, Bemus Point, N. Y., July 25, 1937, H. Townes (Townes).

*Paratypes*: ♀, Nain, Labrador, Aug. 17, 1908, Owen Bryant (Washington). ♂, Bar Harbor, Me., Aug. 23, 1938, A. E. Brower (Townes). ♀, Casco, Me., Aug. 9, 1944, J. C. Bradley (Townes). ♂, Laurel Lake, Jacksonville, Vt., July 30, 1939, H. D. Pratt (St. Paul). ♀, Gould, Compton Co., Que., reared in 1941 from *Pteronidea limbata* (Ottawa).

### Genus *Ctenochira*<sup>3</sup>

Figures 6 to 11

*Ctenochira* Foerster, 1855. Verh. Naturh. Ver. Preuss. Rheinlande 12: 226. *Type*: *Ctenochira bisinuata* Foerster. Monobasic.

*Ctenacme* Foerster, 1868. Verh. Naturh. Ver. Preuss. Rheinlande 25: 196. New synonymy. *Type*: *Polyblastus scutellatus* Thomson (= *scutellaris* Thomson). Designated by Morley 1913.

*Scopiorus* Foerster, 1868. Verh. Naturh. Ver. Preuss. Rheinlande 25: 196. New synonymy. *Type*: *Polyblastus marginatus* Holmgren. Designated by Viereck 1914.

*Gemophaga* Foerster, 1868. Verh. Naturh. Ver. Preuss. Rheinlande 25: 211. *Type*: *Gemophaga rufa* Ashmead. Included by Ashmead 1902.

*Ctenacmus* Thomson, 1883. Opusc. Ent. 9: 901. New synonymy. *Type*: *Polyblastus (Ctenacmus) genalis* Thomson. Designated by Viereck 1914, when he listed this species as the type of *Ctenacme* Foerster and *Ctenacmus* Thomson as an emendation of *Ctenacme*.

*Trichocalymmus* Thomson, 1883. Opusc. Ent. 9: 903. New synonymy. *Type*: *Tryphon propinquus* Gravenhorst. Designated by Viereck 1914.

*Exochoblastus* Schmiedeknecht, 1912. Opusc. Ichneum. fasc. 30: 2401; fasc. 31: 2468. New synonymy. *Type*: *Exochoblastus oreophilus* Schmiedeknecht. Monobasic.

*Scopimenus* Roman, 1937. Ent. Mo. Mag. 74: 64. New synonymy. *Type*: *Scopimenus pygobarbus* Roman. Monobasic.

*Ovipositor sheath* broad, with a dorsal apical emargination; clypeus relatively narrow; second tergite usually with a broad, shallow, transverse groove.

Fore wing 4.0 to 7.5 mm. long; body short and stout; clypeus oval, evenly convex or with a weak subapical transverse impression, its apical margin without a fringe of setae; clypeal foveae rarely enlarged and filled with long setae; cheek 0.25 to 0.65 the basal width of the mandible; posterior mandibular condyles not as far apart as are the

<sup>3</sup>We are indebted to Mr. J. F. Perkins for calling our attention to the proper application of the name *Ctenochira*. Foerster's detailed original description leaves no doubt of the genus he had before him.

eyes at the level of the clypeal foveae; female flagellum with areas of sensory setae occupying the under side of the median segments; outer face of mandible at its basal 0.2 strongly convex, with a few weak punctures; postero-lateral corner of pronotum not unusually heavy nor projecting; subtegular ridge unspecialized, or in *C. subcrassa* rather strongly projecting and containing a deep slot (fig. 11); tegula convex; female with mesosternum and under side of fore and middle coxae with a brush of long suberect silky hairs (this absent in other genera of the tribe); areolet present or absent, when present oblique; second recurrent vein evenly curved, with two well separated bullae; nervellus broken at its lower 0.2 to 0.4; tarsal claws pectinate nearly or quite to the apex; second tergite usually with a postmedian, broad, shallow, transverse groove, usually more or less rugulose and mat, and often more or less punctate; female subgenital plate with rather long, erect or suberect pubescence; ovipositor sheath broad, with an apical dorsal emargination extending 0.2 to 0.7 its length, not flexible except at the base (figs. 6 to 10); ovipositor decurved, evenly tapered to a slender point, about 0.3 as long as the abdomen (fig. 8).

This genus is related to *Polyblastus* and *Erromenus*, as noted under *Polyblastus*.

The species of *Ctenochira* are numerous, variable, and rather closely related. Specimens are scarce in collections, and probably a large per cent of the species are yet to be discovered. Besides those treated, some additional species are present in the material before us but are represented by one or a very few specimens: too few for description in a group as variable as this. Some of the best characters are in the shape and vestiture of the ovipositor sheath, hairs on the female subgenital plate, and the distribution of patches of sensory hairs on the under side of the female flagellum. Their unisexual nature prevents emphasis in the key to species, and the key is constructed largely on "artificial" characters. The species before us seem divisible into three groups.

1. *Subcrassa* group. Second tergite with a postmedian, broad, shallow, transverse impression; ovipositor sheath 1.5 to 2.0 as long as wide, with an apical dorsal emargination extending 0.6 to 0.7 its length (fig. 6); areolet present. Included are the Nearctic *subcrassa*, *debilis*, *tetrica*, and *adepts*.

2. *Propinqua* group. Second tergite with a postmedian, broad, shallow, transverse impression; ovipositor sheath 1.8 to 3.8 as long as wide, with an apical dorsal emargination extending 0.25 to 0.4 its length (figs. 7 to 10); areolet present or absent. The species included are the Nearctic *rufa*, *melina*, *analis*, *gagates*, *gillettei*, *quebecensis*, *inflata*, *potens*, *pectoralis*, *pikonematis*, *infans*, *extricata*, *dilatata*, *rubicunda*, *ferrugata*, *picta*, and *frigida*, and the Palearctic *Tryphon propinquus* Gravenhorst 1829, *Polyblastus rivalis* Holmgren 1855, and *Exochoblastus oreophilus* Schmiedeknecht 1912. *Oreophila* is the type of *Exochoblastus*. A female specimen that has been studied represents nothing more than an aberrant species of this group, with the cheek very short (about 0.25 as long as the basal width of the mandible), the face rather protuberant, the pecten teeth of the tarsal claws very short, the areolet unusually large, and the body unusually short and stout.

Probably the majority of the Palearctic as well as of the Nearctic

species belong to the *propinqua* group, but the only Palaearctic species examined are those mentioned above.

3. *Pygobarbus* group. Second tergite without a transverse impression; ovipositor sheath about 1.1 to 1.3 as long as wide, with an apical dorsal emargination extending about 0.3 its length; areolet absent; abdomen rather elongate. Included are the Nearctic *deplanata* and the Palaearctic *Scopimemus pygobarbus* Roman 1937.

#### KEY TO THE AMERICAN SPECIES OF CTENOCHIRA

1. Flagellum with a broad median white band. . . . . 2  
Flagellum entirely dark. . . . . 3
2. Body largely ferruginous; hind tibia stramineous, blackish apically and subbasally. . . . . 20. *picta*  
Body entirely black, hind tibia entirely blackish. . . . . 6. *melina*
3. Subtegular ridge prominent, containing a deep longitudinal slot in its posterior half (fig. 11); areolet present. . . . . 1. *subcrassa*  
Subtegular ridge not containing a slot, but with a deep furrow just below its posterior part. . . . . 4
4. Rim of antennal socket laterally about as high as the diameter of the first flagellar segment; face entirely or mostly yellow; costula complete; areolet present. . . . . 7. *analis*  
Rim of antennal socket laterally not as high as the diameter of the first flagellar segment; face variously colored, seldom yellow; costula usually incomplete or absent; areolet often absent. . . . . 5
5. Metapleurum and third tergite both punctate with moderately coarse punctures; first and second lateral areas of propodeum with a few or many coarse punctures. . . . . 6  
Metapleurum and third tergite not both conspicuously punctate; first and second lateral areas of propodeum without distinct punctures. . . . . 7
6. Face about 1.80 as wide as long (from lower margin of antennal sockets to clypeal foveae); clothing hairs of ovipositor sheath long, of irregular length, and rather sparse; costula lacking; hind femur ferruginous. . . . . 9. *gillettei*  
Face about 1.75 as wide as long; clothing hairs of ovipositor sheath short, of even length, and rather dense; costula often present; hind femur black or ferruginous. . . . . 8. *gagates*
7. Second tergite without a postmedian transverse groove; mesoscutum except at the margin very sparsely and finely punctate; body depressed; face yellow. . . . . 22. *deplanata*  
Second tergite with a postmedian weak transverse groove; mesoscutum with distinct, moderately dense punctures; body not depressed; face variously colored. . . . . 8
8. Second tergite black, often with a narrow pale apical margin. . . . . 9  
Second tergite entirely or mostly ferruginous (*infans* runs in either half of this couplet). . . . . 16
9. Front of scape and more or less of the face white or pale yellow. . . . . 10  
Front of scape black to light brown; face black, sometimes with the lower lateral corners white. . . . . 12
10. Face with its white markings more or less interrupted or reduced by black vertical lines or areas; metapleurum of male black; female with second segment of middle tarsus longer than wide. . . . . 14. *pikonematis*  
Face whitish all of the way across; metapleurum of male ferruginous; female with second segment of middle tarsus wider than long. . . . . 11
11. Female flagellum with ventral sensory areas beginning on the second segment, its fifth segment about 1.2 as long as wide; second tergite not rugulose, strongly and uniformly mat. . . . . 11. *inflata*  
Female flagellum with ventral sensory areas beginning weakly on the fourth segment and definitely on the fifth, the fifth segment about 1.9 as long as wide; second tergite usually rugulose, polished to mat. . . . . 10. *quebecensis*
12. Second tergite polished, without sculpture; femora black, their apices more or less brown. . . . . 3. *tetrica*  
Second tergite punctate, mat, or otherwise sculptured; femora more or less ferruginous. . . . . 13

13. Hind tibia with a subbasal blackish band, sometimes also with a broad external blackish stripe so that the subbasal blackish band appears as a broadening of the external stripe; ovipositor sheath about 3.3 as long as wide (fig. 8); epipleurum of fourth tergite of female separated from the tergite by a crease. .... 21. *frigida*  
Hind tibia without a subbasal blackish band; ovipositor sheath about 2.2 as long as wide; epipleurum of fourth tergite of female not separated from the tergite by a crease. .... 14
14. Apex of hind tibia not distinctly darkened; hind coxa usually partly or entirely black or piceous; first tergite of female with median carinae on about its basal 0.5. .... 15. *infans*  
Apex of hind tibia more or less distinctly darkened; hind coxa ferruginous; first tergite of female with median carinae on about its basal 0.75. .... 15
15. Tegula white; lower half of thorax of female ferruginous; second segment of middle tarsus of female longer than wide. .... 13. *pectoralis*  
Tegula ferruginous to black; thorax of female entirely black; second segment of middle tarsus of female wider than long. .... 12. *potens*
16. Upper margin of ovipositor sheath with an inconspicuous oblique truncation occupying its apical 0.24, the sheath broadly rounded apically (fig. 7); mesoscutum usually ferruginous, or when occasionally black the coxae usually black also; fore wing about 6.0 mm. long; a large robust species, 5. *rufa*  
Upper margin of ovipositor sheath with a conspicuous truncation or emargination occupying its apical 0.3 to 0.7, the sheath more or less pointed apically (as in figs. 6, 8, 9, and 10); mesoscutum usually black; coxae ferruginous except in *C. infans*; fore wing about 4.0 to 6.5 mm. long; smaller, more slender species. .... 17
17. Mesoscutum ferruginous. .... 18  
Mesoscutum black. .... 19
18. Tegula white; second segment of female middle tarsus about 1.6 as long as wide. .... 18. *rubicunda*  
Tegula ferruginous; second segment of female middle tarsus about 2.0 as long as wide. .... 19. *ferrugata*
19. Areolet present in specimens at hand (but presumably sometimes lacking); upper margin of ovipositor sheath with a truncation or emargination occupying about 0.65 its length. .... 20  
Arolet absent in specimens at hand (but presumably sometimes present); upper margin of ovipositor sheath with a truncation or emargination occupying 0.3 to 0.4 its length. .... 21
20. Body very stout, the second tergite of the female about 0.45 as long as wide (male unknown); second segment of fore and middle tarsi of female wider than long. .... 4. *adepts*  
Body rather slender, the second tergite of the female about 0.56 as long as wide and of the male about 0.63 as long as wide; second segment of fore and middle tarsi of female longer than wide. .... 2. *debilis*
21. Posterior corner of pronotum white; face with at least the lower lateral corners ivory, usually entirely ivory white; temple sloping, in lateral view less than 1.2 as long as the eye. .... 22  
Posterior corner of pronotum not white; face black; temple full, in lateral view more than 1.2 as long as the eye. .... 23
22. Apex of hind femur above and of hind tibia distinctly infusate; face entirely ivory except often for a median dorsal black triangle. East of the Rocky Mountains. .... 17a. *dilatata dilatata*  
Apex of hind femur not infusate; apex of the hind tibia not or slightly infusate; face white with a median vertical dark stripe, to black with the lower lateral corners white. West of the Rocky Mountains, 17b. *dilatata niveicola*
23. Abdomen entirely ferruginous; hairs on median part of female subgenital plate suberect, sloping slightly backwards; first tergite of female with the median dorsal carinae ending at about its apical 0.8. .... 16. *extricata*  
Abdomen largely black; hairs on median part of female subgenital plate sloping slightly forward; first tergite of female with the median dorsal carinae ending at about its middle. .... 15. *infans*

1. *Ctenochira subcrassa* Cresson, new combination

Figures 6 and 11

*Tryphon subcrassus* Cresson, 1868. Trans. Amer. Ent. Soc. 2: 109. Type: ♀, Mass. (Philadelphia).

*Subtegular ridge with a deep longitudinal slot in its posterior half.*

Fore wing about 5.2 mm. long; face about 1.7 as wide as long, its lateral third with small punctures separated by about 2.0 their diameter; fifth flagellar segment of male (as seen from below) about 1.9 as long as wide, of female about 2.2 as long as wide; female flagellum with ventral sensory areas beginning on fourth segment; mesopleurum and metapleurum with small punctures separated by about 4.0 their diameter; subtegular ridge (fig. 11) more prominent than in other species of the genus, its posterior half with a deep longitudinal slot (this absent in other species of the genus); dorsal part of propodeum polished, smooth to somewhat rugulose, impunctate; combined areola and basal area about 1.1 as long as the petiolar area; costula strong to weak or incomplete; areolet present; second segment of middle tarsus about 2.0 as long as wide in the male and 1.25 as long as wide in the female; second tergite of male about 0.65 as long as wide, polished, strongly longitudinally rugulose and weakly mat on the basal 0.8; second tergite of female about 0.56 as long as wide, polished, the basal 0.5 medially weakly rugulose and mat; epipleurum of fourth segment separated from the tergite by a weak fold in the male, not separated in the female; pubescence on female subgenital plate short, dense, sloping slightly backwards; ovipositor sheath about 1.5 as long as wide, its apical dorsal emargination extending about 0.6 its length (fig. 6), its clothing hair rather dense, of moderate length, the hair bases separated by about 0.3 the length of the hairs.

Black. Basal half of mandible and tegula white; clypeus except on its basal 0.2 stramineous; apical half of mandible, palpi, and legs ferruginous, the hind tarsi, hind tibia apically, sometimes the hind tibia largely, and sometimes the hind femur apically above infusate; pedicel externally and often the scape externally more or less pale; flagellum red brown beneath, darker above; hind corner of pronotum dark ferruginous; abdomen ferruginous, the fifth and following tergites black; first tergite infusate basally in the female, more extensively blackish in the male; fourth, third, and rarely the second tergite of the male sometimes more or less blackish; ovipositor sheath and male claspers blackish.

*Specimens:* ♂, Bilby, Alta., July 14, 1924, O. Bryant (Townes); ♂, Smithers, B. C., July 4, 1924, E. R. Buckell (Ottawa). 2 ♀, Martha's Vineyard, Mass., Aug. 5 and 28, F. M. Jones (Townes). ♀, Moorestown, N. J., July 12, 1939, H. & M. Townes (Townes). ♀, Greenport, N. Y., (Washington). ♂, Otsego Lake, N. Y., June 28, 1935, H. Townes (Townes). ♂, 32 miles east of Pineville, Ore., July 22, 1935, Joe Schuh (Corvallis).

2. *Ctenochira debilis*, new species

*Arolet present; second tergite not punctate; face and thorax black; hind tibia uniformly ferruginous; subtegular ridge not containing a longitudinal slot.*

Fore wing about 5.0 mm. long; face about 1.4 as wide as long, its lateral third with small to medium sized punctures separated by 2.0 to 1.2 their diameter; fifth flagellar segment of male (as seen from below) about 1.9 as long as wide, of female about 2.3 as long as wide; female flagellum with ventral sensory areas beginning on the fifth segment; mesopleurum with very small to moderately small punctures separated by about 3.5 their diameter; metapleurum not distinctly punctate; dorsal part of propodeum polished, weakly rugulose, impunctate; combined basal area and areola about 1.4 as long as the petiolar area; costula strong to weak or incomplete; areolet present; second segment of middle tarsus about 2.2 as long as wide in the male and 1.5 as long as wide in the female; second tergite of male about 0.63 as long as wide, polished, the basal 0.75 distinctly rugulose; second tergite of female about 0.56 as long as wide, polished, the basal 0.75 indistinctly rugulose; epipleurum of fourth segment of male separated from the tergite by a weak fold, of the female not separated; pubescence on female subgenital plate short, dense, sloping slightly backwards; ovipositor sheath about 1.75 as long as wide, its apical dorsal emargination extending about 0.6 its length, its clothing hair rather dense, of moderate length, the hair bases separated by about 0.3 the length of the hairs.

Black. Tegula and basal half of mandible whitish; clypeus except its basal 0.2 stramineous; apical half of mandible, palpi, extreme hind corner of pronotum, legs, abdomen except for the basal  $0.5\pm$  of first segment, ovipositor sheath, and male clasper ferruginous, the hind tibia quite uniformly ferruginous; under side of female flagellum reddish-brown. Sometimes the hind coxa basally and the abdominal tergites, especially beyond the third tergite, are more or less infuscate. The ovipositor sheath of the paratype female is blackish.

*Type:* ♀, among forest underbrush at Round Pass, Mt. Rainier, Wash., 3800 ft., July 7, 1940, H. & M. Townes (Townes).

*Paratypes:* ♂, Laggan, Alta., Aug. 26, 1925, O. Bryant (Washington). ♂, Cameron Pass, Colo., Aug. 19, 1940, C. E. Mickel (St. Paul). ♀, Missoula, Mont., July 6, 1917, H. G. Dyar (Townes). ♂, Mt. Rainier, Wash., 2900 ft., July 7, 1940, H. & M. Townes (Townes). ♂, Mt. Rainier, Wash., 5300 ft., Aug. 16, 1940, H. & M. Townes (Townes). ♂, collected with the type (Townes).

### 3. *Ctenochira tetrica*, new species

*Body black; femora black with brownish apices; second tergite polished, without sculpture.*

*Female type:* Fore wing 5.0 mm. long; face 1.8 as wide as long, its lateral third with fine punctures separated by about 2.0 their diameter; fifth flagellar segment (as seen from below) 1.7 as long as wide; sensory areas beginning on the apical half of the third flagellar segment; mesopleurum with small punctures separated by about 3.0 their diameter; metapleurum impunctate; dorsal part of propodeum polished, impunctate; combined basal area and areola 1.3 as long as the petiolar area; costula absent; areolet present; second segment of middle tarsus 1.8 as long as wide; second tergite 0.60 as long as wide, polished, without sculpture, its postmedian transverse furrow very weak; epipleurum of fourth segment not separated from its tergite by a fold; pubescence of subgenital plate short, dense, sloping slightly backwards; ovipositor

sheath 2.3 as long as wide, its apical dorsal emargination extending 0.67 its length, its clothing hairs rather dense, of moderate length, their sockets separated by about 0.3 the length of the hairs.

Black. Clypeus except on its basal 0.25, mandible except basally, palpi, anterior 0.35 of tegula, broad apex of front femur, narrow apices of middle and hind femora, tibiae, tarsi, subgenital plate, and ovipositor sheath brown; apical 0.65 of tegula white.

Type: ♀, Trail Ridge Road, Rocky Mt. National Park, Colo., 12,200 ft., Aug. 25, 1933, M. & H. James (Townes).

#### 4. *Ctenochira adeps*, new species

*Areolet present; second segment of female abdomen about 0.45 as long as wide; apical dorsal emargination of ovipositor sheath extending about 0.7 its length; subtegular ridge not containing a deep longitudinal slot.*

Female type: Fore wing 5.3 mm. long; face 1.6 as wide as long, its lateral third with rather small punctures separated by about 1.5 their diameter; fifth flagellar segment (as seen from below) 1.8 as long as wide; flagellum with ventral sensory areas beginning on the fifth segment; mesopleurum with moderately small punctures separated by about 2.5 their diameter; metapleurum not distinctly punctate; dorsal part of propodeum slightly mat, somewhat rugulose, and with a few indistinct punctures; combined basal area and areola 0.9 as long as the petiolar area; costula complete, rather strong; areolet present; second segment of middle tarsus 0.9 as long as wide; second tergite 0.45 as long as wide, indistinctly mat; epipleurum of fourth segment not separated from the tergite by a fold; pubescence on subgenital plate short, dense, sloping slightly backwards; ovipositor sheath 1.6 as long as wide, its apical dorsal emargination extending 0.7 its length, its clothing hairs rather dense, of moderate length, the hair bases separated by about 0.4 the length of the hairs.

Black. Clypeus, cheek, ventro-lateral corners of face, basal half of mandible, and tegula whitish; apical half of mandible, palpi, legs, and first three tergites ferruginous, the first tergite infusate basally; posterior corner of pronotum and an indistinct longitudinal stripe on ventral part of mesopleurum dark ferruginous; flagellum brown, blackish above, especially towards the base; ovipositor sheath blackish, vaguely stained with ferruginous.

Type: ♀, Stewart Park, Ithaca, N. Y., May 25, 1939, H. Townes (Townes).

#### 5. *Ctenochira rufa* Ashmead, new combination

##### Figure 7

*Trophoctonus insularis* Ashmead, 1902. Proc. Wash. Acad. Sci. 4: 215. Type: ♂, Popof Is., Alaska (Washington).

*Gemophaga rufa* Ashmead, 1902. Proc. Wash. Acad. Sci. 4: 223. Type: ♂, Popof Is., Alaska (Washington).

*Ovipositor sheath short and stout, with an evenly rounded apex, its clothing hairs very dense and short; thorax usually mostly ferruginous, when entirely black the coxae and first trochanters also black.*

Fore wing about 6.0 mm. long; face about 1.75 as wide as long, its lateral third with moderate sized punctures separated by about 1.2 their diameter; fifth flagellar segment of male (as seen from below) about 1.8 as long as wide, of female about 1.6 as long as wide; female flagellum with ventral sensory areas beginning on the fourth or fifth segment; mesopleurum with moderate sized punctures separated by about 1.5 their diameter; metapleurum usually impunctate, but sometimes with small punctures; dorsal part of propodeum polished and more or less rugulose, impunctate; combined basal area and areola about 0.9 as long as the petiolar area; costula strong to weak, incomplete, or almost absent; areolet present or absent; second segment of middle tarsus of male about 1.8 as long as wide, of female about 1.1 as long as wide; second tergite about 0.5 as long as wide, strongly mat, the apical 0.15 to 0.2 subpolished, in the male the basal 0.85 somewhat rugulose as well as mat; epipleurum of fourth segment of male separated from the tergite by a fold, of the female not separated; female subgenital plate with erect, rather long, moderately dense pubescence; ovipositor sheath short and stout with an evenly rounded apex, (with a more or less pointed apex in other species), about 1.7 as long as wide and with its apical dorsal emargination extending about 0.24 its length (fig. 7); clothing hairs of ovipositor sheath very dense and short. The figure of the ovipositor sheath is from a dorso-lateral view. From a strictly side view the apical dorsal notch is hardly visible and the end of the sheath almost evenly rounded.

Ferruginous, marked with black to a varying degree. Typically marked with black only on the propleura, thoracic sterna, thorax in the region of the sutures, some of occiput, base of first tergite, and often on the apex of the middle and hind femora above. Apical part of hind tibia often infusate. Sometimes the black covers all the head but the clypeus, mouthparts, and whitish facial markings, all the thorax including the tegula, the coxae, first trochanters, all but the apex of the first tergite, and apical part of the abdomen. Clypeus except at the base, basal half of mandible, cheek, usually most of the face, and often under side of scape yellowish white. Facial whitish markings sometimes reduced to the ventro-lateral corners. Palpi and flagellum ferruginous to fusco-ferruginous.

*Specimens:* ♀, Mt. McKinley National Park, Alaska, 1932, F. W. Morand (Townes). ♀, Banff, Alta., June 23, 1922, C. B. D. Garrett (Ottawa). ♀, Elk Creek, Fraser, Grand Co., Colo., July 7 to 9, 1927, J. C. Bradley (Ithaca). ♀, Chambers' Lake, Colo., July 18, 1895, C. F. Baker (Washington). 2 ♀, Fort Collins, Colo., Gillette (Philadelphia, paratypes of *Scopiorus gillettei*); ♂, Arenac Co., Mich., June 3, 1939, R. R. Dreisbach (Townes). ♀, LaPeer Co., Mich., May 30, 1937, R. R. Dreisbach (Townes). ♀, Glen House, N. H. June 11 1916 (Cambridge). ♂, Mt. Marcy, N. Y., July 5, J. N. Belkin (Townes). ♀, Cameron Bay, Great Bear Lake, N. W. T., July 28, 1937, T. N. Freeman (Ottawa). ♀, Sudbury, Ont., June 16, 1892 (Ottawa). ♀, Spring Brook, Pa., May 17, 1945, H. Townes (Townes). ♀, Mt. Rainier, Wash., 4700 ft., July 11, 1904, H. & M. Townes (Townes).

This species is transcontinental in the Hudsonian and Canadian zones.



6. *Ctenochira melina*, new name

*Polyblastus annulicornis* Provancher, 1886. Addit. Faune Canad. Hymen., p. 108. Preoccupied by Giraud 1871. Type: ♂ (not ♀), Lake Brome, Knowlton, Que. (Quebec).

*Flagellum with a median white band; abdomen and hind legs entirely black.*

Male: Fore wing 6.0 mm. long; face 1.7 as wide as long, its lateral third with moderate sized punctures separated by about 1.2 their diameter; fifth flagellar segment (as seen from below) 2.1 as long as wide; mesopleurum with medium sized punctures separated by about 2.5 their diameter; metapleurum indistinctly and weakly punctate; dorsal part of propodeum polished, somewhat rugulose, impunctate; combined basal area and areola 0.6 as long as the petiolar area; costula complete, rather strong; areolet present; second segment of middle tarsus 1.6 as long as wide; second tergite 0.55 as long as wide, strongly mat and rugulose, the apical 0.12 smoother and subpolished; epipleurum of fourth segment not separated from the tergite by a fold.

Black. Cheek, ventro-lateral corner of face, and flagellar segments 5 to 11 white; clypeus, mouth parts, and front and middle tarsi brown; front and middle coxae, trochanters, and femora piceous.

*Specimen*: ♂, Waskesiu, Sask., June 20, 1938, J. G. Rempel (Townes).

7. *Ctenochira analis* Cresson, new combination

## Figure 9

*Tryphon analis* Cresson, 1864. Proc. Ent. Soc. Phila. 3: 279. Type, ♂, Pa. (Philadelphia).

*Tryphon occidentalis* Cresson, 1868. Trans. Amer. Ent. Soc. 2: 109. Type: ♀, Ill. (Philadelphia).

*Face yellow; rim of antennal socket laterally as high as the diameter of the first flagellar segment.*

Fore wing about 5.5 mm. long; face about 1.55 as wide as long, its lateral third with medium sized punctures separated by about 1.0 their diameter; rim of antennal socket laterally about as high as the diameter of the first flagellar segment (not so high in other Nearctic species); fifth segment of male flagellum (as seen from below) about 2.1 as long as wide, of female about 2.4 as long as wide; female flagellum with ventral sensory areas beginning on the sixth segment; mesopleurum with medium sized punctures separated by about 2.5 their diameter; metapleurum with indistinct, weak punctures; dorsal part of propodeum polished, weakly rugulose, impunctate; combined basal area and areola about 1.0 as long as the petiolar area; costula complete, usually strong; areolet present; second segment of middle tarsus of male about 1.9 as long as wide, of female about 1.7 as long as wide; second tergite 0.62 as long as wide in the male and about 0.58 as long as wide in the female; second tergite polished, its basal 0.85 punctato-rugulose or rugulose, strongly so in the male and more weakly in the female; epipleurum of fourth segment separated from the tergite by a weak fold in the male and by a very weak fold in the female; female subgenital plate with short dense pubescence that is slanted slightly backwards; ovipositor sheath about 3.0 as long as wide, its apical dorsal emargination extend-

ing about 0.28 its length (fig. 9); clothing hairs of ovipositor sheath dense, the hair bases separated by about 0.3 the length of the hairs.

Black. Face, clypeus, mouth parts except apex of mandible, under side of scape and pedicel, tegula, and trochanters yellow. Face sometimes with a median line, the clypeal groove, and dorsal sublateral triangles brown or black. Usually there are other variable yellow marks, averaging more extensive in the female, as follows: cheek, lower part of temple, lower part to most of propleurum, pro- and mesosterna, and under side of coxae. Legs ferruginous except where yellow (as noted above) and sometimes more or less piceous or infuscate as follows: usually apex of hind femur above, apex of hind tibia and apical part of hind tarsus, rarely the hind femur entirely and the middle femur posteriorly, often more or less of the hind coxa, and occasionally more or less of the middle and fore coxae. Tergites one to four ferruginous, in the female the basal  $0.2\pm$  of the first tergite blackish, in the male the basal  $0.5\pm$  of the first tergite and sometimes more or less of the fourth tergite blackish; ovipositor sheath and male clasper blackish.

Two females from Cannon Beach, Oregon, differ from all other specimens in lacking an apical dorsal infuscation on the hind femur, indicating that more material will show the Vancouverian Zone to harbor a distinguishable race.

*Specimens:* ♂, Bilby, Alta., June 21, 1924, G. Salt (Washington). ♂, Wabamun, Alta., Aug. 2, 1929, E. H. Strickland (Townes). ♂, Rabbit Ears Pass, Colo., July 21, 1896, C. F. Baker (Washington). ♀, Lebanon, Conn., Aug. 18, 1946, M. Townes (Townes). ♀, Great Pond, Mt. Desert, Me., July 16, 1918, C. W. Johnson (Washington). ♂, Southwest Harbor, Me., July 14, 1925, C. W. Johnson (Washington). ♂, Labrador Lake, Cortland Co., N. Y., June 10, 1921 (Ithaca). ♂, Millwood, N. Y., June 27, 1936, H. Townes (Townes). ♂, Mud Creek, Tompkins Co., N. Y., June 17 to 20, 1904 (Ithaca). ♂, Oneonta, N. Y., Aug. 17, 1935, H. Townes (Townes). ♀, Clingmans Dome, N. C., 6600 ft., Aug. 29, 1939, H. & M. Townes (Townes). ♂, Sudbury, Ont., June 17, 1892 (Ottawa). 2 ♀, Cannon Beach, Oreg., Aug. 11, 1940, H. & M. Townes (Townes). 2 ♂, Westerly, R. I., June 27, 1946, M. Townes (Townes). ♂, Prince Albert National Park, Sask., July 20, 1941, J. G. Rempel (Townes).

This is a summer species, transcontinental in the Canadian and Transitional zones.

### 8. *Ctenochira gagates*, new species

*Both metapleurum and second tergite conspicuously punctate; clothing hairs of ovipositor sheath short and dense; face about 1.75 as wide as long.*

Forewing about 6.0 mm. long; face about 1.75 as wide as long, its lateral third with rather large punctures separated by about 1.2 their diameter; fifth segment of flagellum of both sexes (as seen from below) about 2.1 as long as wide; female flagellum with the ventral sensory areas beginning on the fourth segment; meso- and metapleurum with rather large punctures, separated by about 1.3 their diameter on the mesopleurum and by about 1.5 their diameter on the metapleurum; dorsal part of propodeum polished, smooth or weakly rugulose, with

numerous large punctures; combined basal area and areola about 1.0 as long as the petiolar area; costula usually complete, but often incomplete or almost absent; areolet present; second segment of middle tarsus of both sexes about 2.0 as long as wide; tarsal claws rather evenly and weakly curved, near the apex slightly broadened and scoop-shaped (in all other Nearctic species except *gillettei* the tarsal claws have a stronger subapical curve and are tapered to a sharp point); second tergite of male about 0.65 as long as wide, of female about 0.55 as long as wide; second tergite with large punctures separated by about 0.8 their diameter, weaker on the apical 0.2, in the male the tergite also longitudinally rugulose on its basal 0.8; epipleurum of fourth segment separated from the tergite by a fold in the male, but not in the female; female subgenital plate with erect, short, dense pubescence; ovipositor sheath about 2.2 as long as wide, its apical dorsal emargination extending about 0.30 its length; clothing hairs on ovipositor sheath short and dense, the hair sockets separated by about 0.4 the length of the hairs.

Black. Clypeus except its basal 0.15, basal half of mandible, and tegula pale yellow; palpi brown; scape often yellowish in front; apical half of mandible, sometimes all of the legs, and sometimes all of the abdomen except the basal 0.6 of first tergite and infuscation on the apical segments, ferruginous. The legs frequently have the coxae, trochanters, and most or all of the hind femur black, and the tarsi and basal part of the fore and middle femora infusate. The black area on the abdomen may include all but the third tergite, apical 0.5 of second tergite, and all but the apical margin of the fourth tergite. Ovipositor sheath dark brown.

*Type:* ♀, Yakima Park, Mt. Rainier, Wash., 6500 ft., July 22, 1940, H. & M. Townes (Townes).

*Paratypes:* 2 ♂, Mt. McKinley, Alaska, 1932, F. W. Morand (Washington). ♀, Bilby, Alta., June 19, 1924, G. Salt (Townes). ♂, Gleichen, Alta., June 3, 1938, R. W. Salt (Townes). 2 ♂, Cameron Pass, Colo., July 30 and 31, 1896, C. F. Baker (Washington). ♂, Colo. (Washington). ♂, Dafoe, Sask., July 7, 1943, J. G. Rempel (Townes). ♂, Regina, Sask., June 14, 1940, J. G. Rempel (Townes). ♂, Sisseton Indian Reservation, South Dakota, June 23, 1927, H. C. Severin (Townes). ♂, Mt. Rainier, Wash., 5500 ft., July 23, 1940, H. & M. Townes (Townes). ♀, Mt. Rainier, Wash., 6318 ft., Aug. 13, 1931, J. Wilcox (Corvallis).

#### 9. *Ctenochira gillettei* Davis, new combination

Figure 10

*Scopiorus gillettei* Davis, 1897. Trans. Amer. Ent. Soc. 24: 258. Type: ♀, Colo. (Philadelphia).

*Scopiorus expansa* Davis, 1897. Trans. Amer. Ent. Soc. 24: 258. Type: ♂, Mont. (Philadelphia). New synonymy.

*Polyblastus scopioroides* Hall, 1919. Psyche. 26: 156. Type: ♂, Woods Hole, Mass. (Cambridge).

*Both metapleurum and second tergite conspicuously punctate; clothing hairs of ovipositor sheath long, of irregular length; face about 1.8 as wide as long.*

Fore wing about 5.5 mm. long; face about 1.8 as wide as long, its lateral third with large punctures separated by about 0.8 their diam-

eter; fifth segment of flagellum of both sexes (as seen from below) about 2.0 as long as wide; female flagellum with ventral sensory areas beginning on the fourth or fifth segment; meso- metapleurum with rather large punctures, separated by about 0.8 their diameter on the mesopleurum and by about 1.0 their diameter on the metapleurum; dorsal part of propodeum polished, smooth or weakly rugulose, with numerous large punctures; combined basal area and areola about 1.1 as long as the petiolar area; costula absent or occasionally incomplete; areolet present; second segment of middle tarsus of male about 2.5 as long as wide, of female about 1.8 as long as wide; tarsal claws rather evenly and weakly curved, near the apex slightly broadened and scoop-shaped (in all other Nearctic species except *gagates* the tarsal claws have a stronger subapical curve and are tapered to a sharp point); second tergite of male about 0.56 as long as wide, with large punctures separated by about 2.0 their diameter, and the basal 0.75 of the tergite more or less longitudinally rugulose; second tergite of female about 0.52 as long as wide, with large punctures separated by about 1.5 their diameter; epipleurum of fourth segment separated from the tergite by a fold in the male, but not in the female; female subgenital plate with moderately short, dense, erect pubescence; ovipositor sheath about 2.3 as long as wide, its apical dorsal emargination extending about 0.25 its length (fig. 10); clothing hairs of ovipositor sheath long, of irregular length, the hair sockets separated by about 0.5 the average length of the hairs.

Black. Tegula and basal 0.65 of mandible pale yellow; clypeus except for its basal 0.2 =, apical 0.35 of mandible, palpi, postero-lateral corner of pronotum, legs, and abdomen ferruginous, the legs and abdomen marked with black or infusate as follows: coxae sometimes blackish basally; apical dorsal part of hind femur, hind tarsus, and hind tibia externally and apically infusate; first tergite blackish basally in the female, entirely black except for the apical 0.12 to 0.4 in male; third tergite rarely somewhat infusate; fourth and following tergites black or infusate; ovipositor sheath and male clasper ferruginous, often somewhat infusate. Scape and pedicel yellowish ferruginous, more or less infusate above. Flagellum somewhat ferruginous beneath to almost entirely ferruginous.

Occasional female specimens have all dark markings replaced by ferruginous. The type of *Scopiorus gillettei* is of this color variety. Other ferruginous specimens are: ♀, Vernon, (?B. C.), June 9, 1918, W. B. Anderson (Ottawa); and ♀, Cameron Pass, Colo., Aug. 19, 1940, C. E. Mickel (St. Paul). The type of *Scopiorus expansa*, a male from Montana, appears somewhat intermediate between the present species and *gagates*, but more probably belongs here.

*Specimens*: Many males and females from Alberta (Billby, Edmonton, Orkney District, and Waterton); COLORADO (Cameron Pass); CONNECTICUT (Hartford); IDAHO (New Meadow at 3860 ft.); ILLINOIS (Watseka); MASSACHUSETTS (Amherst, Dorchester, Minot Co., South Hadley, Wellesley, and Woods Hole); MINNESOTA (Itasca Park); NEW JERSEY (Ramsey); NEW YORK (near Caroline, Ithaca, Junius, Peru, Rome, near Slaterville, Syracuse, and Utica); ONTARIO (Grimsby, Jordan, Ridgeway, Trenton, and Wabamicon); PENNSYLVANIA (Mt.

Holly Springs and Philadelphia); OREGON (Klamath Falls); QUEBEC (Brome, Gracefield, Hull, Montreal, and St. Anne's); and RHODE ISLAND (Westerly).

This species is transcontinental in the Transitional Zone. It is normally on the wing from late May through June, but a single female was taken at Cameron Pass, Colo., on August 19. Other early and late seasonal records are May 16 at South Hadley, Mass.; May 27 at Wellesley, Mass.; May 28 at Syracuse, N. Y.; June 1 at Brome, Quebec; June 28 at Ithaca, N. Y.; June 29 at Montreal, Que., and June 30 at Waterton, Alta.

#### 10. *Ctenochira quebecensis* Provancher, new combination

*Euceros Quebecensis* Provancher, 1874. Nat. Canad. 6: 30. Type: ♀, Que. (Quebec).

*Tryphon flavifrons* Fyles, 1893. Canad. Ent. 25: 107. Types: ♀♀, ex *Nematus* on *Populus*, Que. (lost).

*Scopiorus monticola* Brues, 1907. Bull. Wis. Nat. Hist. Soc. 5: 56. Type: ♀, Colorado Springs, Colo., 5915 ft. (Lawrence).

*Tergites black; face and scape in front yellowish white, the face without extensive blackish areas; metapleurum ferruginous; second segment of middle tarsus of female wider than long; fifth flagellar segment of female 1.9 as long as wide, of male 2.1 as long as wide.*

Fore wing about 5.5 mm. long; face about 1.85 as wide as long, its lateral third with small punctures separated by about 3.0 their diameter; fifth segment of male flagellum (as seen from below) about 2.1 as long as wide, of female flagellum about 1.9 as long as wide; ventral sensory areas of female flagellum beginning weakly on the fourth segment and definitely on the fifth; mesopleurum with rather small punctures separated by about 3.0 their diameter; metapleurum weakly mat and rugulose, not distinctly punctate; dorsal part of propodeum somewhat mat, largely rugulose, and with a few indistinct punctures; combined basal area and areola about 0.8 as long as the petiolar area; costula weak or absent, rarely rather strong; areolet absent; second segment of middle tarsus of male about 1.4 as long as wide, of female about 0.9 as long as wide; second tergite of male about 0.59 and of female about 0.51 as long as wide; second tergite with the apical 0.18 subpolished, the rest mat and rugulose, more strongly so in the male; epipleurum of fourth segment separated from the tergite by a fold in the male, but not in the female; female subgenital plate with moderately long, moderately dense, erect pubescence; ovipositor sheath about 2.3 as long as wide, its apical dorsal emargination occupying about 0.27 its length; clothing hairs of ovipositor sheath rather sparse, their sockets separated by about 0.8 their length.

Black. Face except for a median dorsal triangle, clypeus, mouth-parts except apical part of mandible, cheek, lower part of temple, under side of scape, pedicel, basal flagellar segments, hind corner of pronotum, and tegula yellowish white; under side of flagellum more or less distinctly ferruginous; lower 0.65± of mesopleurum, often the lower part of propleurum, metapleurum, thoracic sterna, and more or less of the pleural parts of the propodeum ferruginous, the mesosternum sometimes with fuscous areas; apical part of hind tibia fuscous; hind

tarsus fuscous except that the basal 0.75 of its basitarsus is whitish; tergites and ovipositor sheath black, the apical margins of the tergites more or less distinctly ferruginous.

*Specimens:* ♂, 2 ♀, Riley Co., Kans., April 16, 17, and 18, F. Marlatt (Washington and Townes). 2 ♂, Plymouth, Mass., July 3, 1906, E. A. Back (Washington). ♀, reared from *Pteronidea ventralis*, Berthierville, Que., Sept. 4, 1939, L. Daviault (Ottawa). ♂, reared from "*Nematus pallidiventris*" (Washington). ♀, no data (Washington). The types are from Colorado Springs, Colo., and from Quebec.

### 11. *Ctenochira inflata*, new species

*Tergites black; face and scape in front yellowish white, the face without extensive blackish areas; second segment of middle tarsus of female about as wide as long; fifth segment of female flagellum about 1.2 as long as wide.*

Female type: Fore wing 6.3 mm. long; face 1.35 as wide as long, its lateral third with small punctures separated by about 1.5 their diameter; fifth flagellar segment (as seen from below) 1.2 as long as wide; flagellum with ventral sensory areas beginning on the second segment; mesopleurum with small punctures separated by about 2.0 their diameter; metapleurum mat, with small weak punctures separated by about 2.0 their diameter; dorsal part of propodeum mat, weakly rugulose, impunctate; combined basal area and areola 0.9 as long as the petiolar area; costula absent; areolet absent; second segment of middle tarsus 1.1 as long as wide; second tergite 0.50 as long as wide, strongly mat, the apical 0.2 smoother; epipleurum of fourth segment not separated from the tergite by a fold; subgenital plate with short, dense pubescence with a slight backward slant; ovipositor sheath 2.2 as long as wide, its apical dorsal notch extending 0.28 its length; clothing hairs of ovipositor sheath rather sparse and short, the hair sockets separated by about 0.8 the length of the hairs.

Black. Face except for a median dorsal triangle, clypeus, mouthparts except apical part of mandible, cheek, lower part of temple, under side of scape, under side of pedicel, under side of basal flagellar segments, hind corner of pronotum, thoracic sterna, lower half of mesopleurum, and tegula yellowish white; under side of flagellum except basally and apically pale ferruginous; legs pale ferruginous, the hind tibia infuscate apically and the hind tarsus fuscous with the basal 0.75 of the basitarsus whitish; postero-lateral part of propodeum, metapleurum, and lower 0.7 of mesopleurum ferruginous, grading into the yellow of the sterna; apical margins of tergites ferruginous; ovipositor sheath black.

*Type:* ♀, Ithaca, N. Y., June 7, 1940, H. & M. Townes (Townes).

### 12. *Ctenochira potens*, new species

*Tergites black; front of scape brown to black; tegula ferruginous to black; hind tibia ferruginous, somewhat infuscate apically.*

Female: Fore wing about 7.0 mm. long; face about 1.75 as wide as long, its lateral third with medium sized punctures separated by about 1.2 their diameter; fifth flagellar segment (as seen from below) about 2.1 as long as wide; flagellum with ventral sensory areas beginning on

the fourth segment, or as a trace on the third; mesopleurum with medium sized punctures separated by about 2.5 their diameter; metapleurum with weak, medium sized punctures separated by about 2.0 their diameter; dorsal surface of propodeum polished, weakly rugulose; combined basal area and areola about 1.05 as long as the petiolar area; costula absent; areolet absent; second segment of middle tarsus about 1.0 as long as wide; second tergite about 0.58 as long as wide, its apical 0.25 subpolished, the rest mat and ruguloso-punctate; epipleurum of fourth segment not separated from the tergite by a fold; subgenital plate with moderately long, moderately dense, erect pubescence; ovipositor sheath about 2.2 as long as wide, its apical dorsal notch occupying about 0.30 its length; clothing hairs of ovipositor sheath rather sparse, their sockets separated by about 0.8 their length.

Black. Clypeus except the basal 0.2 and mandibles yellowish, the mandible black at its base and ferruginous apically; palpi brown; scape and flagellum obscurely ferruginous beneath; tegula black or dark brown; legs dark ferruginous, the hind tibia apically and the hind tarsus infuscate. The paratype has an ill-defined whitish spot in the ventro-lateral corner of the face.

*Type:* ♀, Nelson, B. C., June 1, 1927, A. A. Dennys (Ottawa).

*Paratype:* ♀, Mt. McKinley National Park, Alaska, 1932, F. W. Morand (Washington).

### 13. *Ctenochira pectoralis*, new species

*Tergites black; front of scape brown to black; tegula whitish; hind tibia ferruginous, somewhat infuscate apically.*

Fore wing about 4.8 mm. long; face about 1.65 as wide as long, its lateral third with small punctures separated by about 2.0 their diameter; fifth flagellar segment (as seen from below) about 1.7 as long as wide in the male and about 2.0 as long as wide in the female; female flagellum with ventral sensory areas beginning on the fifth or sixth segment; mesopleurum with small punctures separated by about 3.5 their diameter; metapleurum impunctate; dorsal surface of propodeum polished, weakly rugulose; combined basal area and areola about 0.95 as long as the petiolar area; costula complete or incomplete; areolet absent; second segment of middle tarsus about 1.8 as long as wide in the male and about 1.2 as long as wide in the female; second tergite of male about 0.58 as long as wide, of female about 0.54 as long as wide; apical 0.25 of second tergite subpolished, the rest more or less mat and longitudinally rugulose, strongly so in the male; epipleurum of fourth segment not separated from the tergite by a fold; female subgenital plate with long erect pubescence, not especially dense; ovipositor sheath about 2.0 as long as wide, its apical dorsal notch extending 0.30 its length; clothing hairs of ovipositor sheath very sparse, their sockets separated by about 1.5 their length.

Black. Clypeus except its basal 0.12, basal 0.6 of mandible, often more or less of the cheek, more or less of the posterolateral corner of the pronotum, and tegula white; palpi and legs ferruginous, the hind tibia apically and the hind tarsus fuscous. In the male there is an ill-defined dark ferruginous area below the middle of the mesopleurum.

In the female the following parts of the thorax are ferruginous: lower part of propleurum, lower 0.65 of mesopleurum and adjacent part of propodeum, thoracic sterna, and a small lateral area on the collar. Under side of antenna more or less brownish or dusky ferruginous.

*Type*: ♀, Lac Mercier, Que., Aug. 12, 1937, G. S. Walley (Ottawa).

*Paratypes*: 2 ♂, Mt. Pisgah, N. C., 5000 to 5749 ft., Sept. 5, 1939, H. & M. Townes (Townes). ♀, Macdiarmid, Lake Nipigon, Ont., July 7, 1923, N. K. Bigelow (Ottawa).

#### 14. *Ctenochira pikonematis*, new species

*Scopiorus quebecensis* Brown, 1941. Tech. Bull. Canad. Dept. Agr. 31: 6. Misidentified.

*Tergites black; scape whitish in front; face white with vertical blackish lines or areas of varying size; metapleurum of male black; second segment of middle tarsus of female longer than wide.*

Fore wing about 5.5 mm. long; face about 1.75 as wide as long, its lateral third with moderately small punctures separated by about 1.5 their diameter; fifth flagellar segment (as seen from below) about 2.0 as long as wide in the male and about 2.3 as long as wide in the female; ventral sensory areas of female flagellum beginning on the fifth segment; mesopleurum with medium sized punctures separated by about 2.0 their diameter; metapleurum impunctate to indistinctly punctate, often weakly rugulose and mat; dorsal surface of propodeum subpolished, more or less rugulose, sometimes with some indistinct punctures; combined basal area and areola about 0.9 as long as the petiolar area; costula weak or absent; areolet absent; second segment of middle tarsus about 2.5 as long as wide in the male and about 1.25 as long as wide in the female; second tergite about 0.61 as long as wide in the male and about 0.56 as long as wide in the female; second tergite with the apical 0.25 subpolished, in the male with the basal 0.75 mat and more or less rugulose, in the female with the basal 0.75 mat to subpolished, sometimes weakly rugulose and sometimes with indistinct punctures; epipleurum of fourth segment separated from the tergite by a fold in the male, but not in the female; female subgenital plate with long, rather sparse setae slanted slightly forward; ovipositor sheath about 2.0 as long as wide, its apical dorsal notch occupying about 0.26 its length; ovipositor sheath with suberect setae and with a few subapical short erect setae, but without clothing hairs.

Black. Clypeus, mandible except at the base and apically, palpi, cheek, under side of scape and pedicel, tegula, and usually the extreme hind corner of the pronotum white; face with broad lateral marks and usually also with a median V- or U-shaped mark or pair of longitudinal streaks white; female with the thoracic sterna, lower 0.6 of mesopleurum, and the metapleurum ferruginous; male with the mesosternum and lower part of the mesopleurum often more or less distinctly ferruginous; legs ferruginous, the hind tarsus fuscous and the hind tibia apically infusate or all but its basal part infusate; flagellum more or less brownish or ferruginous beneath, especially in the female; apical margins of tergites more or less distinctly ferruginous.

*Type*: ♀, Cascapedia River, Que., July 12, 1935, M. L. Prebble (Ottawa).



*Paratypes*: ♀, reared from a larva of *Pikonema alaskensis* collected at Grand Is., Mich., July 28, 1907 (Washington). ♀, Upper Ten Mile, Ore., Aug. 2, 1931 (Corvallis). 2 ♂, Cascapedia River, Que., July 6 and 7, 1935, M. L. Prebble (Ottawa). 15 ♂, 1 ♀, reared in 1939 and 1941 from Quebec by the Canadian Forest Insect Survey, from *Pikonema alaskensis*, (5 localities), from *Pikonema dimmockii* (5 localities), and from *Pikonema* sp., the localities as follows: Franquelin, Havre St. Pierre, Kamouraska, Maniwaki, Moisie River, Restigouche, Riv. au Tonverre, St. Urbain, Temiscouata, and several other localities not decipherable from the labels (Ottawa). ♂, ex *Pikonema alaskensis*, Thwart Is., Newfoundland, emerged in incubator April 10, 1939 (Ottawa).

This species is transcontinental in the Canadian Zone and a common parasite of *Pikonema* (Tenthredinidae).

### 15. *Ctenochira infans*, new species

*Face black; hind tibia uniformly ferruginous; areolet absent; first tergite of female broad, with the median dorsal carinae ending near its middle.*

Fore wing about 5.0 mm. long; face about 1.75 as wide as long, its lateral third with moderately small punctures separated by about 1.5 their diameter; fifth flagellar segment (as seen from below) about 1.7 as long as wide in the male and 1.85 as long as wide in the female; female flagellum with ventral sensory areas beginning on the third or as a trace on the second segment; mesopleurum with rather small punctures separated by about 1.5 their diameter; metapleurum with more or less distinct small punctures separated by about 2.0 their diameter, all but its upper third rugulose; dorsal surface of propodeum polished, more or less rugulose, impunctate; combined basal area and areola about 1.1 as long as the petiolar area; costula usually absent, sometimes weak or incomplete; areolet absent; second segment of middle tarsus about 2.3 as long as wide in the male and about 1.15 as long as wide in the female; median dorsal carinae of second tergite ending near its midlength in the female, extending farther in the male; second tergite about 0.55 as long as wide in the male and 0.50 as long as wide in the female; second tergite mat, the basal 0.8 in the female more or less longitudinally rugoso-punctate, in the male strongly longitudinally rugoso-punctate; epipleurum of fourth segment not separated from the tergite by a fold; pubescence of female subgenital plate moderately long, dense, erect or slanted a little forward; ovipositor sheath about 2.3 as long as wide, its apical dorsal notch occupying about 0.30 its length; clothing hairs of ovipositor sheath rather long and sparse, their sockets separated by about 0.8 their length.

Black. Clypeus and basal 0.6 of mandible yellowish; palpi and apical 0.4 of mandible ferruginous; under side of antenna more or less stained with ferruginous; tegula white; legs ferruginous, often the coxae and trochanters more or less blackish, sometimes the femora basally infusate, often the hind tarsus infusate, and sometimes the apical part of the hind tibia faintly infusate; abdomen either entirely black or ferruginous marked as follows: basal 0.75 to entire first tergite

black, second tergite often blackish basally, and abdomen beyond the third or fourth tergites infuscate or black.

*Type:* ♀, Mt. McKinley National Park, Alaska, 1932, F. W. Morand (Washington).

*Paratypes:* 3 ♀, Churchill, Man., Aug. 2 to 9, 1937, R. H. Daggy (St. Paul and Washington). 5 ♂, 6 ♀, collected with the type (Washington and Townes).

The female paratypes from Churchill are somewhat more extensively ferruginous and have the tarsal and flagellar segments longer than in the series from Mt. McKinley. Their fifth flagellar segment averages 1.95 as long as wide and their second segment of the middle tarsus 1.8 as long as wide.

#### 16. *Ctenochira extricata* Davis, new combination

*Scopiorus extricatus* Davis, 1897. Trans. Amer. Ent. Soc. 24: 259. Type: ♀, Colo. (Philadelphia).

*Face black; abdomen and hind tibia entirely ferruginous; areolet absent.*

Female: Fore wing about 5.7 mm. long; face about 1.65 as wide as long, its lateral third with moderately small punctures separated by about 1.5 their diameter; fifth flagellar segment (as seen from below) about 1.8 as long as wide; ventral sensory areas of flagellum beginning on the third segment; mesopleurum with medium sized punctures separated by about 1.4 their diameter; metapleurum impunctate or with a few medium sized punctures, more or less mat and with its lower 0.5 rugose; dorsal surface of propodeum subpolished or somewhat mat, rather smooth; combined basal area and areola about 1.1 as long as the petiolar area; costula absent; areolet absent; second segment of middle tarsus about 1.15 as long as wide; second tergite about 0.57 as long as wide, mat and weakly rugulose, the apical 0.25 smoother and more polished; epipleurum of fourth segment not separated from the tergite by a fold; pubescence on subgenital plate rather short, dense, and with a distinct backward slope; ovipositor sheath about 2.1 as long as wide, its apical dorsal notch occupying about 0.37 its length; clothing hairs of ovipositor sheath moderately dense, their sockets separated by about 0.4 their length.

Black. Clypeus except its basal 0.15 and basal 0.6 of mandible yellowish white; apical 0.4 of mandible, palpi, legs, and abdomen ferruginous; tegula white; ovipositor ferruginous basally, the rest more or less black; apex of hind femur and of hind tibia sometimes lightly infuscate.

*Specimens:* ♀, Banff, Alta., July 14, 1938, C. H. Townes (Townes). 2 ♀, 5 miles south of The Dalles, Ore., May 5, 1938, K. Gray and J. Schuh (Corvallis and Townes). ♀, bred from "willow sawfly," Wenatchee, Wash., May 23, 1916, E. J. Newcomer (Washington).

#### 17. *Ctenochira dilatata* Provancher

*Face usually more or less ivory white; mesoscutum black; third tergite ferruginous; areolet absent.*

Fore wing about 4.8 mm. long; face about 1.63 as long as wide, its lateral third with small punctures separated by about 2.0 their diam-

eter; fifth flagellar segment (as seen from below) about 1.9 as long as wide in the male and 2.0 as long as wide in the female; ventral sensory areas of female flagellum beginning on the fifth segment; mesopleurum with very small punctures separated by about 3.0 their diameter; metapleurum not distinctly punctate; dorsal surface of propodeum polished, weakly rugulose or almost smooth, impunctate; combined basal area and areola about 1.1 as long as the petiolar area; costula absent, or sometimes present and weak; areolet absent; second segment of middle tarsus about 1.7 as long as wide in the male and 1.4 as long as wide in the female; second tergite about 0.59 as long as wide in the male and 0.57 as long as wide in the female, the tergite subpolished and longitudinally rugulose, coarsely so in the male and weakly so in the female, its apical 0.25 subpolished and smooth; epipleurum of fourth segment not separated from the tergite by a fold; pubescence of female subgenital plate rather short, dense, and slanted somewhat forward; ovipositor sheath about 2.2 as long as wide, its apical dorsal notch occupying about 0.35 its length; clothing hairs of ovipositor sheath rather sparse, their sockets separated by about 0.8 their length.

*Ctenochira dilatata* is divisible into two subspecies, one east and one west of the Rocky Mountains. They may be differentiated on color as described below.

17a. *Ctenochira dilatata dilatata* Provancher, new combination

*Catocentrus dilatatus* Provancher, 1875. Nat. Canad. 7: 316. Type: ♂, Que. (Quebec).

Black. Face except for a narrow median dorsal triangle extending about half its length, cheek, clypeus, basal half of mandible, palpi, scape and pedicel beneath, postero-lateral corner of pronotum, and tegula white; flagellum more or less ferruginous beneath, paler in the female than in the male, and in the female the basal one or two segments whitish beneath; legs ferruginous, the hind femur somewhat infusate above at its apex, the hind tibia blackish apically and often somewhat infusate subbasally, and the hind tarsus infusate; first tergite ferruginous or usually more or less black; second tergite ferruginous or often more or less black, sometimes entirely black except at the base and apex; third tergite ferruginous to black except at the base; fourth and following tergites black, the fourth tergite sometimes with ferruginous marks; ovipositor sheath and male clasper black.

*Specimens:* ♂, 10 miles east of Washington, D. C., July 11, 1926, H. S. Barber (Washington). ♀, The Pas, Man., Aug. 11, 1937, D. G. Denning (St. Paul). ♀, Bowie, Md., May 30, 1945, H. & M. Townes (Townes). ♂, South Hadley, Mass., Oct. 1, 1935, M. Townes (Townes). ♂, Hanover, N. H., C. M. Weed (Washington). ♀, McLean, N. Y., Aug. 31, 1925 (Ithaca). ♀, Milford Center, N. Y., Aug. 13, 1935, H. Townes (Townes). ♀, Oneonta, N. Y., Aug. 24, 1935, H. Townes (Townes). ♂, ♀, Pisgah Mt., N. C., 5000 to 5749 ft., Sept. 5, 1939, H. & M. Townes (Townes). 5 ♂, ♀, Pisgah Mt., N. C., 4800 to 5300 ft., June 21, 1940, H. & M. Townes (Townes). ♀, Georgeville, Que., May 20, 1936, G. S. Walley (Ottawa). ♀, Hull, Que., Aug. 14, 1897, Harrington (Ottawa). ♀, Oct. 3, 1897 (no further data, but apparently

labeled by Harrington and therefore from the vicinity of Ottawa, Ont.) (Ottawa).

This subspecies occurs in the east, from Manitoba and Quebec south to North Carolina. It is on the wing from late spring until fall.

17b. *Ctenochira dilatata niveicola* Ashmead, new combination

*Scorpiorus* (!) *alaskensis* Ashmead, 1902. Proc. Wash. Acad. Sci. 4: 214. Type: ♀, Popof Is., Alaska (Washington). New synonymy.

*Scorpiorus* (!) *niveicola* Ashmead, 1902. Proc. Wash. Acad. Sci. 4: 214. Lectotype hereby selected: ♂, Popof Is., Alaska, July 9, 1899, T. Kincaid (Washington).

*Scorpiorus plagosus* Hall, 1919. Psyche 26: 159. Type: ♀, Yellowstone Park, Wyo., 8200 ft. (Cambridge). New synonymy.

Differs from *Ctenochira dilatata dilatata* only in color as follows: Face with a median vertical black stripe of varying width separating the lateral whitish areas, sometimes the face entirely black or with a white spot in the ventro-lateral corner; clypeal suture between the foveae blackish; white of cheek sometimes reduced to a small spot; apex of hind femur not infuscate; sometimes the hind tibia and tarsus without infuscation; fourth and following tergites black to blackish stained with ferruginous.

*Specimens*: ♀, Muir Inlet, Alaska, June 12, 1899, T. Kincaid (Washington, paratype of *niveicola*). ♂, Edmonton, Alta., July 6, 1932, O. Peck (Ottawa). ♂, Inverness, Calif., May 22, 1940, E. C. VanDyke (San Francisco). ♀, Inverness, Calif., Oct. 6, 1946, H. Townes (Townes). ♂, ♀, Cannon Beach, Ore., Aug. 6, 1940, H. & M. Townes (Townes). ♀, Mt. Rainier, Wash., 4700 ft., July 11, 1940, H. & M. Townes (Townes).

This subspecies occurs in Alaska and in the United States and Canada west of the Rocky Mountains.

18. *Ctenochira rubicunda*, new species

*Thorax ferruginous; face whitish with light ferruginous stains; tegula white.*

Female type: Fore wing 5.3 mm. long; face 1.75 as wide as long, its lateral third with small punctures separated by about 2.0 their diameter; fifth flagellar segment (as seen from below) 2.4 as long as wide; ventral sensory areas of flagellum beginning on the fourth segment; mesopleurum with medium sized punctures separated by about 1.2 their diameter; metapleurum with rather small weak punctures separated by about 1.2 their diameter; dorsal surface of propodeum polished, with indistinct weak punctures; combined basal area and areola 0.9 as long as the petiolar area; costula absent; areolet absent; second segment of middle tarsus 1.6 as long as wide; second tergite 0.42 as long as wide, weakly punctato-rugulose, the apical 0.2 smoother; epipleurum of fourth segment separated from the tergite by a weak fold; pubescence on subgenital plate rather short, dense, and slanting somewhat forward; ovipositor sheath 2.0 as long as wide, its apical dorsal notch occupying 0.27 its length; clothing hairs of ovipositor sheath moderately long and sparse, their sockets separated by about 0.3 their length.

Ferruginous. Clypeus, cheek, and face whitish, with light ferruginous stains; tegula white; part of frons and most of top of head and

occiput infusate; scape and pedicel pale ferruginous anteriorly, the pedicel and upper part of scape infusate posteriorly; most thoracic sutures, propodeal carinae, and base of first tergite blackish; apex of hind femur and of hind tibia lightly infusate; fifth and following tergites and the ovipositor sheath fusco-ferruginous.

*Type*: ♀, reared from a sawfly cocoon, Fredericton, N. B., May 31, 1933, C. E. Atwood (Ottawa).

#### 19. *Ctenochira ferrugata*, new species

*Mesoscutum, face, and tegula ferruginous; second segment of middle tarsus of female about 2.0 as long as wide.*

Female: Fore wing about 5.5 mm. long; face about 1.75 as wide as long, its lateral third with small punctures separated by about 1.8 their diameter; fifth flagellar segment (as seen from below) about 2.0 as long as wide; ventral sensory areas of flagellum beginning on the fourth segment, with a trace on the third; mesopleurum with medium sized punctures separated by about 1.7 their diameter; metapleurum impunctate or with weak indistinct punctures; dorsal surface of propodeum polished, smooth, impunctate; combined basal area and areola about 1.0 as long as the petiolar area; costula absent; areolet present or absent; second segment of middle tarsus about 2.0 as long as wide; second tergite about 0.54 as long as wide, weakly punctato-rugulose, the apical 0.2 smoother; epipleurum of fourth segment separated from the tergite by a weak fold; pubescence of subgenital plate of moderate length, rather dense, erect; ovipositor sheath about 2.5 as long as wide, its apical dorsal emargination occupying about 0.34 its length; clothing hairs of ovipositor sheath rather dense, their sockets separated by about 0.3 their length.

Ferruginous. Clypeus, mouthparts, and lower lateral corners of face pale ferruginous; occiput, most of the thoracic sutures, propodeal carinae, and extreme base of first tergite black; flagellum somewhat infusate above, especially towards the base; legs uniformly ferruginous.

*Type*: ♀, Lake George, Mt. Rainier, Wash., 4200 ft., July 15, 1940, H. & M. Townes (Townes).

*Paratype*: ♀, collected with the type (Townes).

#### 20. *Ctenochira picta*, new species

*Flagellum with a median white band; abdomen, hind femur, and propodeum ferruginous.*

Female: Fore wing about 5.5 mm. long; face about 1.6 as wide as long, its lateral third with small punctures separated by about 1.5 their diameter; fifth flagellar segment (as seen from below) about 2.6 as long as wide; ventral sensory areas of flagellum beginning on the eighth segment; mesopleurum with small punctures separated by about 3.0 their diameter; metapleurum with very small, weak punctures; dorsal surface of propodeum polished, smooth, impunctate; combined basal area and areola about 1.3 as long as the petiolar area; costula weak and incomplete, or absent; areolet absent; second segment of middle tarsus about 2.0 as long as wide; second tergite about 0.52 as long as wide, polished, nearly smooth; epipleurum of fourth segment not sep-

arated from the tergite by a fold; pubescence of subgenital plate short, dense, erect; ovipositor sheath about 3.0 as long as wide, its apical dorsal notch occupying about 0.34 its length; clothing hairs of ovipositor sheath rather dense, their sockets separated by about 0.3 their length.

Ferruginous. Head whitish, the frons except laterally, and the occiput black, the black of the occiput often extended laterally to the upper posterior part of the eye; mouthparts whitish, the apical part of the mandible brownish ferruginous; scape, pedicel, and basal two or three segments of flagellum whitish below and blackish above; remainder of flagellum blackish except for a white band on about the ninth to sixteenth segments; lower part and postero-lateral corner of pronotum, lower part or most of propleurum, mesosternum, lower fourth and anterior margin of mesepisternum, mesepimeron, scutellum, post-scutellum, spot in center of mesoscutum, line along notaulus, a broad lateral mark on the mesoscutum, and tegula white; mesonotum and metanotum black or blackish except where noted as white; upper central part of lateral face of pronotum and upper fourth of mesepisternum black; first and second lateral areas of propodeum sometimes infuscate; trochanters, fore coxae, most of middle coxae, and base of tibiae whitish; hind tibia with a subbasal and an apical fuscous band, its central part stramineous; middle tibia banded like the hind but less distinctly; fore tibia with a subbasal infuscation; hind tarsus stramineous, the apical part of the basitarsus and most of the rest of the segments somewhat infuscate; tergites sometimes infuscate laterally; ovipositor sheath brown.

*Type:* ♀, Westport, Washington, July 17, 1940, H. & M. Townes (Townes).

*Paratypes:* ♀, Robson, B. C., Aug. 6, 1939, H. R. Foxlee (Townes). ♀, Ithaca, N. Y., June 2, 1936, H. Townes (Townes). ♀, Mt. Pisgah, N. C., 5000 to 5749 ft., Sept. 5, 1939, H. & M. Townes (Townes).

## 21. *Ctenochira frigida* Cresson, new combination

### Figure 8

*Bassus frigidus* Cresson, 1868. Trans. Amer. Ent. Soc. 2: 111. Type: ♀, Great Slave Lake, N. W. T. (Philadelphia).

*Tergites black; hind tibia infuscate apically and subbasally, sometimes also externally.*

Fore wing about 5.3 mm. long; face about 1.65 as wide as long, its lateral third with small punctures separated by about 2.0 their diameter; fifth flagellar segment of male (as seen from below) about 2.1 as long as wide, of female about 2.2 as long as wide; ventral sensory areas of female flagellum beginning on the third segment; mesopleurum with small punctures separated by about 2.5 their diameter; metapleurum impunctate or with fine weak punctures; dorsal surface of propodeum polished and more or less rugulose, impunctate; combined basal area and areola about 1.0 as long as the petiolar area; costula weak or absent; areolet absent; second segment of middle tarsus about 1.8 as long as wide in the male and 1.3 as long as wide in the female; second tergite about 0.69 as long as wide in the male and 0.61 as long as wide in the female, strongly mat and finely rugulose, the apical 0.25 smoother;

epipleurum of fourth segment separated from the tergite by a fold; pubescence on female subgenital plate short, dense, and erect; ovipositor sheath about 3.3 as long as wide, its apical dorsal notch occupying about 0.39 its length (fig. 8); clothing hairs of ovipositor sheath rather dense, their sockets separated by about 0.3 their length.

Black. Clypeus except often its basal margin, basal 0.5 of mandible, palpi, usually the hind corner of pronotum, and tegula white; apical 0.5 of mandible ferruginous; female and often the male with metapleurum, lower 0.65 of mesopleurum, mesosternum, and sometimes part of the propleurum ferruginous, the mesosternum sometimes yellowish ferruginous; fore leg ferruginous, its tibia basally whitish; coxae, trochanters, and femora of middle and hind legs ferruginous, the apices of their femora usually infuscate above; hind tibia white to dusky stramineous, with a subbasal and broad apical fuscous band, sometimes the bands connected by a fuscous stripe externally and rarely the hind tibia almost uniformly fuscous except for a pale basal band; hind tarsus blackish, the basal part of the first segment broadly and of the second and third segments more narrowly white or stramineous; middle tibia and tarsus faintly repeating the coloration of the hind tibia and tarsus but usually tinged with ferruginous; apical margin of tergites more or less pale; ovipositor sheath and male claspers black.

*Specimens:* ♂, 5 ♀, Matanuska, Alaska, Sept. 2 to Oct. 6, 1945, J. C. Chamberlin (Washington). ♂, Mt. McKinley National Park, Alaska, 1932, F. W. Morand (Washington). ♀, Bilby, Alta., June 19, 1924, George Salt (Washington). ♀, Edmonton, Alta., Aug. 20, 1932, O. Peck (Townes). ♀, Lake Louise, Alta., July 29, 1938, G. S. Walley (Ottawa). ♀, Vermillion Lake, Banff, Alta., 4500 ft., Aug. 17, 1925, O. Bryant (Washington). ♂, ♀, Cameron Pass, Colo., July 30, 1896, C. F. Baker (Washington). ♀, Forrester's Ranch, Colo., Aug. 3, 1896, C. F. Baker (Washington). ♀, 20 miles south of Churchill, Man., Aug. 5 to 6, 1937, D. G. Denning (St. Paul). ♂, Brevort, Mich., Aug. 9, 1936, C. W. Sabrosky (Townes). ♀, Cameron Bay, Great Bear Lake, N. W. T., July 12, 1937, T. N. Freeman (Ottawa). ♂, Scappoose, Ore., May 5, 1936, Schuh and Gray (Corvallis). 2 ♂, reared from sawfly, Yakima, Wash., May 21, E. J. Newcomer (Washington). ♂, reared from *Pteronidea vancouverensis*, Yakima, Wash., May, 1919, E. J. Newcomer (Washington).

This species is probably transcontinental in the Hudsonian and Canadian zones, but has not yet been taken east of Manitoba and Michigan. The Yakima record indicates that it may also be looked for in the Transitional Zone. The three specimens from Colorado seem to represent a distinct race, lacking the apical infuscation on the middle and hind femora and having the banding on the hind tibia and tarsus quite suffused.

## 22. *Ctenochira deplanata*, new species

*Second tergite without a transverse impression.*

Forewing about 4.6 mm. long; face longitudinally convex, about 1.5 as wide as long, its lateral third with small punctures separated by about 1.5 their diameter; fifth flagellar segment of both sexes (as seen from below) about 1.8 as long as wide; ventral sensory areas of female

flagellum beginning at the apex of the third segment; mesoscutum polished, with sparse, very small punctures, especially sparse in the female (more densely punctate in other Nearctic species); mesopleurum with small punctures separated by about 4.0 their diameter; metapleurum with small punctures separated by about 2.5 their diameter; dorsal surface of propodeum subpolished, largely rugose; combined basal area and areola about 1.25 as long as the petiolar area; costula very weak; areolet absent; second segment of middle tarsus about 2.0 as long as wide in the male and 1.0 as long as wide in the female; second tergite about 0.68 as long as wide in the male and 0.80 as long as wide in the female, subpolished, the basal 0.5 medially longitudinally rugulose, the rest nearly smooth; second tergite without a broad, transverse, weak, postmedian groove (this present in all other Nearctic species); epipleurum of fourth segment of male separated from the tergite on its basal 0.65 by a weak fold, not separated in the female; subgenital plate rather small, its pubescence rather sparse, long, and erect; ovipositor sheath 1.1 as long as wide, its dorsal apical notch extending 0.30 its length; ovipositor sheath with suberect setae but without appressed clothing hairs.

Black. Face, clypeus, sides of frons, cheek, lower end of temple, basal 0.65 of mandible, palpi, ventral and hind parts of pronotum, tegula, coxae except basally, trochanters, and knees yellow; antenna dark brown above, the scape, pedicel, and basal two flagellar segments yellow beneath and the rest of the flagellum light brown beneath; coxae basally ferruginous or in the male the hind coxa black at the base; femora ferruginous except apically, the hind femur darkest; hind tibia and tarsus brownish, the tibia yellow basally; tergites ferruginous, the first tergite black except for its apical margin medially, the second black except for about its apical 0.22, the third with a pair of blackish sub-lateral areas, and in the male the rest of the tergites somewhat darkened ferruginous with the apical part rather yellowish, most broadly yellowish medially; ovipositor sheath and male clasper yellowish.

*Type:* ♀, Isle Royal, Mich., Aug. 3 to 7, 1936, C. Sabrosky (Washington).

*Paratype:* ♂, Pagosa Springs, Colo., C. F. Baker (Washington).

## Genus *Erromenus*

Figures 12 to 21

*Subtegula ridge an upright flange that reaches lower edge of the tegula; ovipositor and its sheath upcurved.*

Fore wing 3.5 to 7.0 mm. long; body and legs very short and stout; clypeus oval, transversely evenly convex, longitudinally convex to almost flat, its apical margin often with an inconspicuous fringe of short setae; clypeal foveae often enlarged and filled with long setae; cheek 0.2 to 0.4 as long as the basal width of the mandible; posterior mandibular condyles a little closer together than are the eyes at the level of the clypeal foveae; outer face of mandible at its basal 0.2 moderately convex to almost flat, with rather large punctures; postero-lateral corner of pronotum somewhat incrassate and projecting a little; subtegular ridge projecting upwards as a thin flange that touches the lower



edge of the tegula when the latter is not raised (figs. 12, 16, and 17); tegula convex; areolet present or absent, when present oblique; second recurrent vein evenly curved, with two widely separated bullae; nervellus broken at its lower 0.2 to 0.35; tarsal claws usually pectinate on their basal 0.5 or more, sometimes on as little as their basal 0.3, and rarely apparently simple; second tergite smooth or with a shallow oblique furrow on each side cutting off the baso-lateral corners, mat to polished, coarsely punctate to impunctate; ovipositor sheath strongly upcurved, rigid, usually quite short (figs. 13 to 15 and 18 to 21); ovipositor upcurved, usually quite short.

*Erromenus* is related to *Polyblastus* and *Ctenochira* as noted under *Polyblastus*.

#### KEY TO THE SUBGENERA OF ERROMENUS

1. Anterior half of margin of subtegular ridge straight or weakly convex, the ridge touching the tegula (when the tegula is not raised) through most of its anterior half (fig. 16); epomia complete and strong, extending well below the pronotal sulcus; tarsal claws pectinate, conspicuously so in the female but often inconspicuously and only basally in the male; latero-apical part of clypeus not impressed; basal corners of petiole not unusually strong; ovipositor larger, its sheath wider and at least 0.7 as long as the subgenital plate (figs. 13 to 15 and 18 to 21); sixth and seventh tergites of female short, each projecting little or not at all beyond the preceding tergite,

subgenus **Erromenus**

Anterior half of margin of subtegular ridge concave and well separated from the tegula (fig. 17); epomia short, weak, and indistinct, not extending below the pronotal sulcus; tarsal claws apparently not pectinate; latero-apical part of clypeus somewhat impressed; basal corners of petiole very strong; ovipositor very small, its sheath narrow, without setae, and only 0.3 as long as the subgenital plate; sixth and seventh tergites of female long, each projecting conspicuously beyond the preceding tergite,

subgenus **Aderaeon**

#### Subgenus **Erromenus**

Figures 12 to 16 and 18 to 21

*Erromenus* Holmgren, 1855. Svenska Vet.-Akad. Handl. 1: 221. Type: *Tryphon brunnicans* Gravenhorst. Designated by Viereck 1912.

? *Trichocalymma* Foerster, 1868. Verh. Naturh. Ver. Preuss. Rheinlande. 25: 196.

Type: *Trichocalymma bipunctatum* Woldstedt. Designated by Viereck, 1914.

*Currana* Viereck, 1924. Can. Ent. 56: 30. Type: (*Currana mirabilis* Viereck) = *analisis* Brischke. Monobasic.

Clypeus with its lateral apical parts not impressed, usually strongly convex; epomia complete and strong, extending well below the pronotal sulcus; anterior half of subtegular ridge straight or weakly convex, the ridge reaching the tegula (when the tegula is not raised) throughout most of its anterior half; tarsal claws pectinate, at least basally, though in males of many species the pectination is so sparse and short as to be difficult to see; basal corners of petiole not unusually strong; sixth and seventh tergites of female each projecting but little or sometimes not at all beyond the preceding tergite; subgenital plate of female not unusually long; ovipositor sheath with a few to many setae, not unusually small and at least 0.7 as long as the subgenital plate.

Most species have a small pale basal mark on the outer side of each tibia, quite distinct in some but indistinct in others.

The American species of the subgenus *Erromenus* divide into four species groups as follows:

1. *Marginatus* group. Seventh tergite of female with a median apical transverse brush of long setae, some with upturned apices (figs. 13 and 14); second tergite with a pair of shallow oblique basal grooves; tarsal claws of female pectinate almost to the apex; areolet present. Included are the Holarctic *analys* and *punctulatus*, the Nearctic *brevipēs*, *levis*, *scorteus*, *marginatus*, *defrictus*, *proteus*, *dimidiatus* and *glabrosus*, the Palaearctic *frenator* Gravenhorst 1829, and doubtless a number of other Palaearctic species. The species *analys* is exceptional in having the apical hair brush of the female seventh tergite reduced to a few setae and the female tarsal claws not pectinate to the apex. *E. glabrosus* has the basal grooves on the second tergite subobsolete. The European *E. brunnicans* Gravenhorst 1829 agrees with this group in the characters stated but has enormous clypeal foveae and the occipital carina rather straight below, instead of incurved sharply to the hypostomal carina.

2. *Ungulatus* group. Seventh tergite of female very deep to accommodate the long ovipositor, but not otherwise specialized (fig. 15); second tergite without oblique basal grooves; ovipositor sheath as long as the first tergite; areolet absent; lower part of mesopleurum with fine sparse punctures. Included is a single Nearctic species, *E. ungulatus*.

3. *Caelator* group. Seventh tergite of female variously modified, apically with rather long erect setae (figs. 19 to 21); second tergite without oblique basal grooves; clypeal foveae very large; ovipositor sheath rather slender; tarsal claws pectinate on about their basal 0.75; areolet present; included are five species differing from one another most clearly in the female seventh tergite. These are the Nearctic *planus*, *caelator*, and *nasalis* and two undetermined European species. We have seen a single female from Jaffrey, N. H. (Cambridge) which appears to represent a fourth Nearctic species (undescribed).

4. *Variolae* group. Seventh tergite of female retractable so that only its apical margin is visible and the apical part of the abdomen appears as a hollow lined largely with intersegmental membrane (fig. 18); ovipositor sheath rather elliptical, flat and polished; tarsal claws of female sparsely pectinate on not more than their basal 0.65; second tergite without oblique basal grooves; occipital carina often not quite reaching the hypostomal carina, or weak or indistinct at its juncture with the hypostomal carina; areolet present or absent. Included are four diverse Nearctic species: *labratus*, *tonto*, *dolichops*, and *variolae*.

#### KEY TO THE AMERICAN SPECIES OF THE SUBGENUS ERROMENUS

1. Second tergite with a pair of shallow oblique basal furrows that cut off its baso-lateral corners to slightly beyond the spiracles, or when the furrows are indistinct (in some *E. glabrosus*), the lateral carina of the scutellum extending 0.8 its length; seventh tergite of female with an apical, usually transverse, brush of setae, of which some have upturned apices (figs. 13 and 14); front tarsal claws of female pectinate practically to the apex (except in *E. analys*), of the male inconspicuously pectinate on the basal 0.4 to 0.75 (*marginatus* group).....2
- Second tergite without distinct oblique basal furrows; seventh tergite without an apical brush of setae, or when there is such a brush (in *E. nasalis*, fig. 21) the apices of the setae are not upturned and the brush is not transverse; front tarsal claws frequently pectinate on less than their basal 0.5.....11

2. Second and third tergites black, blackish, or in *E. levis* reddish brown, each usually with a narrow apical pale border. . . . . 3  
Second and third tergites largely or entirely ferruginous. . . . . 8
3. Face strongly protuberant (especially in the female), its greatest protuberance below the middle; abdomen black, fulvous apically; thorax and abdomen narrower than in any other species of the genus. . . . . 3.  *analis*  
Face less protuberant, its greatest protuberance above the middle. . . . . 4
4. Lower half of mesopleurum with sparse weak punctures separated from one another by about 3 times their diameter; fore wing 3.5 to 4.2 mm. long. . . 5  
Lower half of mesopleurum with moderately dense medium sized punctures separated from one another by 1.2 to 2.5 times their diameter; fore wing 4.5 to 6.0 mm. long. . . . . 6
5. Hind coxa black; second and third tergites sparsely and finely punctate; tarsi slightly shorter than usual. . . . . 1.  *brevipes*  
Hind coxa ferruginous; second and third tergites very sparsely and finely punctate; tarsi of normal length. . . . . 2.  *levis*
6. Petiolar area with a single strong complete median vertical carina; second and third tergites completely mat; coxae usually black. . . . . 5.  *punctulatus*  
Petiolar area without a median vertical carina or with two or three weak and usually incomplete vertical carinae; second and third tergites usually more or less polished; coxae ferruginous. . . . . 7
7. Abdominal tergites with moderately dense punctures, those on the second tergite separated from one another by about 0.5 the length of their setae; lateral portions of mesoscutum with moderately dense punctation, . . . . . 6.  *marginatus*  
Abdominal tergites with sparse punctures, those on the second tergite separated from one another by about 1.0 the length of their setae; lateral portions of mesoscutum with sparse punctation. . . . . 7.  *defricatus*
8. Apical abdominal tergites, beginning with the fourth or fifth, black or strongly infusate; upper margin of antennal socket projecting as a flange about 0.5 as high as the scape is wide; frons strongly impressed near the antennal sockets. . . . . 10.  *dimidiatus*.  
Apical abdominal tergites ferruginous; upper margin of antennal socket forming a weak flange that projects by only about 0.15 the diameter of the scape; frons not strongly impressed near the antennal sockets. . . . . 9
9. Lateral carina of scutellum extending about 0.8 its length; hind part of lateral margin of mesoscutum elevated as a lamina about 0.55 to 0.7 as high as the tegula is wide; wings usually smoky. . . . . 8.  *glabrosus*  
Lateral carina of scutellum extending 0.25 to 0.5 its length; hind part of lateral margin of mesoscutum elevated as a lamina 0.2 to 0.4 as high as the tegula is wide; wings hyaline or subhyaline. . . . . 10
10. Basal carina of propodeum not strongly dipped into the top of the petiolar area, strong and approximately straight across the top of the petiolar area; ovipositor sheath strongly convex apically and at the margins, the rest flatter; second and third tergites distinctly punctate. . . . . 9.  *proteus*  
Basal carina of propodeum strongly dipped into the top of the petiolar area, the dipped portion of the carina weak and irregular; ovipositor sheath rather uniformly convex; second and third tergites mat and very weakly and inconspicuously punctate. . . . . 4.  *scorteus*
11. Lower half of mesopleurum with fine, rather sparse punctures separated from one another by more than 3.0 their diameter; ovipositor sheath about 1.05 as long as the first tergite (fig. 15); areolet absent; femora and tarsi slightly shorter than usual, the hind femur about 0.7 as long as the hind tibia (*ungulatus* group). . . . . 11.  *ungulatus*  
Lower half of mesopleurum with medium sized punctures separated from one another by 1.0 to 1.8 their diameter; ovipositor sheath not more than 0.6 as long as the first tergite (figs. 18 to 21); areolet present or absent; femora and tarsi of normal length, the hind femur about 0.8 as long as the hind tibia. . . . . 12
12. Clypeus very weakly transversely convex, about 2.7 to 3.1 as wide as long; front tarsal claws not pectinate beyond the basal 0.33; abdomen black or black with the apex fulvous; ovipositor and seventh tergite as described in second half of couplet 14 (*variolae* group, in part). . . . . 13  
Clypeus rather strongly transversely convex, about 2.0 to 2.5 as wide as long; front tarsal claws pectinate on their basal 0.4 to 0.75. . . . . 14

13. Femora ferruginous.....15. *labratus*  
Femora black.....16. *tonto*
14. Occipital carina strong and distinct to the hypostomal carina; female with the seventh tergite not capable of complete invagination (figs. 19 to 21); ovipositor sheath convex, tapered to a blunt point (figs. 19 to 21); front tarsal claws of female rather densely pectinate on the basal 0.75 (*caelator* group).....15  
Occipital carina not quite reaching the hypostomal carina or reaching it but weak and indistinct at the juncture; female with the seventh tergite invaginated, or capable of invagination, so that only its apical margin is visible and the apex of the abdomen contains a concave area lined largely with intersegmental membrane (fig. 18); ovipositor sheath rather flat (fig. 18); front tarsal claws of female sparsely pectinate on the basal 0.55 to 0.65 (*variolae* group, in part).....17
15. Seventh tergite of female with a median apical rounded nose-like prominence (fig. 21); second tergite of both sexes punctate and more or less mat.....14. *nasalis*  
Seventh tergite of female without an apical rounded prominence; second tergite of both sexes punctate and polished or slightly mat.....16
16. Seventh tergite of female with a large flattened medioapical area bearing upright setae (fig. 19), the apical margin of the tergite unspecialized (fig. 19A); ovipositor sheath about 0.75 as long as the subgenital plate; hind coxa usually ferruginous.....12. *planus*  
Seventh tergite of female with a median apical chisel-like decurved tooth (figs. 20 and 20A); ovipositor sheath about 1.1 as long as the subgenital plate; hind coxa black.....13. *caelator*
17. Clypeus between the foveae convex in profile, separated from the face by a strong groove; cheek 0.5 to 0.8 as wide as the basal width of the mandible; abdomen usually largely ferruginous; areolet absent.....17. *dolichops*  
Clypeus between the foveae flat in profile, separated from the face only by a difference in sculpture; cheek about 0.3 as wide as the basal width of the mandible; abdomen black; areolet usually present.....18. *variolae*

### 1. *Erromenus* (*Erromenus*) *brevipes*, new species

*Fore wing about 3.8 mm. long; abdomen black, the second tergite with oblique basal grooves; petiolar area without a median vertical carina; coxae usually black; tarsi and femora slightly shorter than usual.*

Fore wing about 3.8 mm. long; cheek about 0.22 as long as the basal width of the mandible; lower half of mesopleurum with fine punctures separated by about 3.0 their diameter; legs unusually short, the hind femur about 0.7 as long as the hind tibia (about 0.8 as long in most species), and the third segment of the front tarsus slightly longer ( $\sigma^7$ ) or slightly shorter ( $\rho$ ) than long; front tarsal claws of male coarsely pectinate on their basal 0.5; petiolar area of moderate size, hexagonal with its top side shortened, without median vertical carinae; second tergite about 0.6 as long as wide, finely and sparsely punctate, subpolished with the basal corners mat; setiferous part of ovipositor sheath about 1.0 as long as subgenital plate. Agrees otherwise with the structural description of *E. marginatus*.

Black. Clypeus and mandible red-brown, both blackish basally; palpi brown; tegula brown; its antero-lateral part paler; coxae black, rarely ferruginous; trochanters black to infusate ferruginous or rarely ferruginous; legs beyond trochanters light ferruginous brown, the femora (especially the hind ones) usually more or less infusate except at the apex; tibiae with an indistinct external basal pale mark; second and following tergites with the apical margin narrowly pale red-brown, the apical segments with the margins slightly wider.

*Type*: ♀, north end of Paradise Valley at 5300 ft. (timberline), Mt. Rainier, Wash., Aug. 16, 1940, H. & M. Townes (Townes).

*Paratypes*: 3 ♂, ♀, collected with the type (Townes). ♀, Sunrise Ridge at 5500 ft. (timberline), Mt. Rainier, Wash., July 23, 1940, H. & M. Townes (Townes).

## 2. *Erromenus* (*Erromenus*) *levis*, new species

*Fore wing about 4.0 mm. long; second and following tergites dark brownish ferruginous margined apically with paler, subpolished and very weakly punctate; lower half of mesopleurum with fine punctures separated by about 3 times their diameter.*

Fore wing about 4.0 mm. long; clypeus about 2.3 as wide as long; cheek about 0.2 as long as the basal width of the mandible; lower half of mesopleurum with fine punctures separated by about 3.0 their diameter; front tarsal claws of male coarsely pectinate on their basal 0.5; petiolar area large, hexagonal with the top side shortened and somewhat concave, without median vertical carinae or with a pair of weak irregular ones; second tergite about 0.6 as long as wide, sparsely punctate with very fine punctures, subpolished with the basal corners mat; setiferous part of ovipositor sheath about 1.0 as long as the subgenital plate. Agrees otherwise with the structural description of *E. marginatus*.

Black. Mandible yellow, apically dark ferruginous; clypeus ferruginous, its basal margin infusate; palpi ochraceous; scape and pedicel ferruginous, infusate above; flagellum dark brown; tegula yellow; legs ferruginous, the tibiae each with a rather distinct external basal pale mark; abdomen dark brownish red, paler apically, the second and following tergites with a narrow ochraceous apical margin, the margin wider on the apical segments.

*Type*: ♀, Taughanick Falls, N. Y., Aug., 1925 (Ithaca).

*Paratypes*: 2 ♂, "on sawfly," no other data (Washington and Townes).

## 3. *Erromenus* (*Erromenus*) *analisis* Brischke

Figure 14

*Erromenus analisis* Brischke, 1871. Schrift. phys.-ökon. Gesell. Königsberg, 11: 95.

Types: ♂, ♀, Prussia.

*Currania mirabilis* Viereck, 1924. Canad. Ent. 56: 301. Type: ♀, Aylmer, Que. (Ottawa). New synonymy.

*Face strongly bulging just above the clypeus; body exceptionally narrow.*

Fore wing about 4.3 mm. long; face very strongly bulging, most strongly bulging just above the clypeus; clypeus transversely convex, longitudinally convex at its extreme base but the rest of its length flat in profile; cheek about 0.2 as long as the basal width of the mandible; mandible exceptionally slender; entire thorax and abdomen exceptionally long and slender, together with the protuberant face giving an *Exochus*-like appearance; lower half of mesopleurum with fine to medium sized punctures separated from one another by 2 to 4 times their diameter; hind part of mesoscutal margin elevated as a narrow lamina about 0.2 as high as the tegula is wide; scutellum with lateral

carinae at its basal corners only; front tarsal claws of both sexes coarsely pectinate on their basal 0.75; combined basal area and areola of propodeum about 1.9 as long as wide; petiolar area circular, narrowly concave at the top, without a median vertical carina; second tergite about 0.85 as long as wide, in the male mat with its apical 0.12 subpolished, in the female subpolished and with sparse fine punctures; sixth and seventh tergites of female each distinctly projecting from the preceding tergite, the seventh compressed and with a small median apical tuft of long setae with upturned tips (fig. 14); setiferous part of ovipositor sheath about 1.0 as long as the subgenital plate. Agrees otherwise with the structural description of *E. marginatus*.

Black. Clypeus and mandibles brownish ferruginous; palpi ochraceous; scape stained with ferruginous beneath; tegula yellow; front and middle coxae ferruginous to black; hind coxa dusky ferruginous to black; legs beyond coxae ferruginous, the hind femur frequently more or less infuscate except at the apex; hind tibia and tarsus sometimes darkened; tibiae each with a distinct basal pale mark; second and following tergites with the apical margin fulvous; apex of abdomen entirely fulvous, in the female sometimes as far basad as the apex of the third tergite, in the male not uniformly fulvous basad of the sixth tergite.

*Specimens:* ♀, Fairbanks, Alaska, June 30, 1921, J. M. Aldrich (Townes). ♀, Jesmond, B. C., Aug. 28, 1938, J. K. Jacob (Ottawa). ♀, Colo. (Washington). ♀, Morley, Colo., Aug. 26, 1940, H. & M. Townes (Townes). ♂, Cranberry Lake, N. Y., Aug. 14, 1924, E. A. Hartley (Washington). ♂, ♀, Cranberry Lake, N. Y., Aug. 19, 1924, E. A. Hartley (Washington and Townes). ♀, Moosonee, Ont., July 19, 1934, G. S. Walley (Ottawa). ♀, Sweetburg, Que., July 6, 1936, G. S. Walley (Ottawa). ♀, Spearfish, S. D., July 26, 1924 (Washington). 2♂, ♀, Mt. Rainier, at 4700 and at 5300 ft., Wash., Aug. 17, 1940, H. & M. Townes (Townes).

This species is transcontinental in the Canadian Zone of North American and occurs also in northern Europe. American specimens have been compared with a female from England, lent to us by Mr. J. F. Perkins of the British Museum. The species has been reared in Europe from *Pontania capreae*.

#### 4. *Erromenus (Erromenus) scorteus*, new species

*Apical propodeal carina strongly dipped into the petiolar area; second tergite mat, not distinctly punctate; abdomen mostly ferruginous.*

Fore wing about 4.8 mm. long; cheek about 0.28 as long as the basal width of the mandible; lower half of mesopleurum punctat rugulose, the punctures weak, separated from one another by about 2 times their diameter; hind part of mesoscutal margin elevated as a lamina that is about 0.25 as high as the tegula is wide; lateral scutellar carina extending about 0.4 its length; front tarsal claws of male coarsely pectinate on about their basal 0.65; combined basal area and areola of propodeum about 1.1 as long as wide; petiolar area of moderate size, hexagonal with its top side strongly concave where the areola pushes downward into the petiolar area, the carina separating the areola and

petiolar area usually weak and irregular; petiolar area without a median vertical carina; second tergite about 0.65 as long as wide, very finely punctate, mat with the apical 0.12 subpolished; setiferous portion of ovipositor sheath about 1.0 as long as the subgenital plate. Agrees otherwise with the structural description of *E. marginatus*.

Black. Clypeus and mandible brownish ferruginous; palpi light brown; tegula light brown, its anterior-lateral part paler; coxae and first trochanters ferruginous piceous to black; second trochanters ferruginous to black; legs beyond trochanters ferruginous, the tibiae each with an indistinct basal pale mark; second and following tergites ferruginous, frequently indefinitely margined laterally with black or blackish; second tergite usually with a large median basal infusate area; third and following tergites often somewhat infusate basally, rarely the apical tergites entirely blackish.

Type: ♀, Snoqualmie Pass, Wash., July 3, 1940, H. & M. Townes (Townes).

Paratypes: ♂, ♀, collected with the type (Townes). ♀, Colo. (Washington). ♂, Mt. Rainier at 5300 ft., Wash., Aug. 17, 1940, H. & M. Townes (Townes).

### 5. *Erromenus* (*Erromenus*) *punctulatus* Holmgren

Figure 12

*Erromenus punctulatus* Holmgren, 1855. Svenska Vet-Akad. Handl. 1: 222. Type: ♂, Sweden (?Stockholm).

*Tryphon crassus* Cresson, 1868. Trans. Amer. Ent. Soc. 2: 107. Type: ♀, New Jersey (Philadelphia). New synonymy.

*Tryphon tejonius* Cresson, 1878. Proc. Acad. Nat. Sci. Phila., p. 372. Type: ♂, Ft. Tejon, Calif. (Philadelphia).

*Polyblastus leviculus* Davis, 1897. Trans. Amer. Ent. Soc. 24: 263. Type: ♂, Colo. (Philadelphia).

*Petiolar area with a strong median vertical carina; abdomen black.*

Fore wing about 5.4 mm. long; cheek about 0.32 as long as the basal width of the mandible; lateral carina of scutellum extending about 0.4 its length; combined basal area and areola of propodeum about 0.9 as long as wide; petiolar area of moderate size, with a single strong vertical carina, rounded hexagonal but its top side deeply notched; lateral section of apical carina sloping upwards from the petiolar area; second tergite about 0.7 as long as wide, very finely punctate, strongly mat with the apical margin subpolished; ovipositor sheath very convex and stubby-looking, its setiferous part about 0.9 as long as the subgenital plate. Agrees otherwise with the structural description of *E. marginatus*.

Black. Clypeus brownish red on its apical 0.7 =; mandible brownish red apically; palpi dark brown; tegula light brown, slightly paler antero-laterally; coxae black, rarely ferruginous or infusate ferruginous; trochanters black to infusate ferruginous or ferruginous; legs beyond trochanters ferruginous; second and following tergites with the apical margin usually narrowly red-brown.

A male from Mt. Marcy, N. Y., has the propodeum quite smooth rather than strongly rugulose as in the rest of the specimens, and the coxae ferruginous but infusate basally. A female from McLean,

N. Y., and another from Keremeos, B. C., have the coxae entirely ferruginous. A female from Beulah, N. M., has the coxae piceous and ferruginous. All other specimens before us have the coxae black. We have compared Nearctic material with a male in the National Museum from Crefeld, Germany, determined as *punctulatus* by Ulbricht, and find no important differences.

*Specimens:* ♂, Edmonton, Alta., May 27, 1924, Owen Bryant (Washington). 4 ♀, Matanuska, Alaska, June 6 to 11, 1945, J. C. Chamberlin (Washington). ♀, Keremeos, B. C., June 18, 1923, C. B. Garrett (Ottawa). ♀, Likely, B. C., July 7, 1938, G. S. Walley (Ottawa). ♀, Bar Harbor, Me., May 26, 1934 (Washington), bred from sawfly. ♂, Mt. Madison, N. H., June 24, 1938, H. & M. Townes (Townes). ♀, Beulah, N. M., June 29, 1902 (Philadelphia). ♀, Artist's Brook, Essex Co., N. Y., June 23, 1940, H. Dietrich (Ithaca). ♀, Connecticut Hill at 2095 ft., Tompkins Co., N. Y. (Townes). ♂, Mt. Marcy, N. Y., June 26, J. N. Belkin (Townes). ♀, McLean, N. Y., May 29, 1937, H. Townes (Townes). ♂, McLean, N. Y., May 31, 1913 (Ithaca). ♀, Saranac Lake, N. Y., July 19, 1946, R. T. Mitchell (Mitchell). ♂, ♀, Sudbury, Ont., June 16 and 17, 1892 (Ottawa). ♂, Hat Point, Wallowa Co., Ore., July 30, 1941, G. R. Ferguson (Corvallis). ♂, Hideaway, Ore., Aug. 14, 1913, W. D. Edmonston (Washington). ♂, Bolton Glen, Que., June 5, 1936, G. S. Walley (Ottawa). ♂, Brome, Que., June 2, 1936, G. S. Walley (Ottawa). ♂, Knowlton, Que., June 11, 1936, G. S. Walley (Ottawa). ♀, Mt. Lyall, Que., June 28, 1933, C. C. Smith (Ottawa). 5 ♂, 10 ♀, Mt. Rainier at 2900 ft., 3800 ft., 4200 ft., 4700 ft., and 5500 ft., Wash., July 7, 15, 19, 21, and 23, 1940, H. & M. Townes (Townes).

In the Nearctic Region this species occurs across the continent in the Canadian and Hudsonian zones. In the Palearctic Region it is known from northern and central Europe. There seems to be a single generation a season. In the southern Canadian Zone, adults appear about May 25; in the Hudsonian Zone as late as the middle of July. The author's experience collecting the species on Mt. Rainier indicates a short period of flight, perhaps two weeks for the period of abundance. It has been reared in Europe from *Amauronematus forsiusi*.

## 6. *Erromenus (Erromenus) marginatus* Provancher

*Erromenus marginatus* Provancher, 1883. Nat. Canad. 14: 10; Faune, p. 797. Type: ♀, Cap Rouge, Que. (Quebec).

*Abdomen black; coxae ferruginous; second tergite of female with moderately coarse punctures separated by about 0.5 the length of their setae; ovipositor sheath convex.*

Fore wing about 5.0 mm. long; face most strongly bulging just below the antennal sockets, medially with rather coarse sharp punctures, sublaterally the punctures finer and denser, and laterally the punctures fine and sparse; clypeus about 2.5 as wide as long, transversely convex and longitudinally convex with a flattening centered just beyond its midlength; clypeal suture a furrow, deepened at the foveae into well-marked somewhat elongate pits that are much narrower than the basal diameter of the apical flagellar segment; cheek about 0.21 as long



as the basal width of the mandible; occipital carina complete, strong at its juncture with the hypostomal carina; lower half of mesopleurum with rather small punctures separated from one another by about 1.5 their diameter; hind part of mesoscutal margin elevated as a lamina that is about 0.3 as high as the tegula is wide; lateral carina of scutellum extending about 0.35 its length; areolet present; front tarsal claws of male sparsely pectinate on their basal 0.75, of the female densely pectinate practically to the tips; combined basal area and areola of propodeum about 1.0 as long as wide; petiolar area large, hexagonal with the top side concave, often with two weak irregular median vertical carinae; lateral section of apical propodeal carina horizontal; dorsal carinae of first tergite strong and sharp, ending about 0.12 from the apex of the tergite; second tergite about 0.63 as long as wide, with a pair of broad shallow oblique basal furrows that cut off its latero-basal corners to a little beyond the spiracle, in and basad of the furrows somewhat more mat and rugose than elsewhere; second tergite of male mat with about the apical 0.15 subpolished, finely to moderately finely punctate; second tergite of female subpolished with the basal corners mat, with moderately coarse punctures; sixth and seventh tergites of female projecting little beyond the previous tergite, the seventh above rounded off, its postero-dorsal face with long setae and its apex with a posteriorly projecting transverse brush of setae, some of which have upturned apices; ovipositor sheath ovate, upcurved, strongly convex, with a mucronate tip, the setiferous part of the sheath about 0.85 as long as the subgenital plate.

Black. Clypeus brownish ferruginous to pale ferruginous, the basal  $0.3\pm$  black; mandible yellow, apically dark ferruginous; palpi pale brownish ferruginous to brown; scape and pedicel somewhat stained with ferruginous below; tegula yellow, apically often somewhat brownish; legs ferruginous, the hind tarsal segments somewhat infusate apically and the tibiae each with a basal external yellow mark; apical margin of second and following tergites brownish ferruginous.

*Specimens:* ♂, Edmonton, Alta., July 25, 1932, O. Peck (Townes). ♀, Edmonton, Alta., Aug. 12, 1932, E. H. Strickland (Townes). ♀, Jesmond, B. C., Aug. 26, 1938, J. K. Jacob (Ottawa). ♀, Barago Co., Mich., Aug. 4, 1937, R. R. Dreisbach (Dreisbach). ♂, Isabella Co., Mich., May 30, 1938, R. R. Dreisbach (Townes). ♀, Isle Royal, Mich., Aug. 3 to 7, 1936, R. R. Dreisbach (Dreisbach). ♀, Douglas Lake, Mich., Aug. 11, 1922 (Ithaca). ♀, Franconia, N. H. (Washington). ♂, Saranac Lake, N. Y., June 6, 1946, R. T. Mitchell (Mitchell). ♂, Cleveland, Ohio, June 9, 1935, C. H. Kennedy (Columbus). ♀, Spring Brook, Pa., Aug. 13, 1944, H. Townes (Townes). ♀, Hazleton, Pa., Sept., 1896, W. G. Dietz (Washington). ♀, Lehigh Gap, Pa., July 24, 1913 (Philadelphia). ♂, Bolton Glen, Que., June 5, 1936, G. S. Walley (Ottawa). ♀, Knowlton, Que., June 15, 1936, G. S. Walley (Ottawa). ♀, Lac Mercier, Que., Aug. 17, 1937, G. S. Walley (Ottawa). ♀, Hopkington, R. I., Aug. 31, 1946, M. Townes (Townes). ♂, Mt. Rainier at 2900 ft., Wash., July 7, 1940, H. & M. Townes (Townes). ♂, Mt. Rainier at 5300 ft., Wash., Aug. 16, 1940, H. & M. Townes (Townes). 3 ♂, bred from larva of "*Nematus*" on *Corylus* by H. G. Dyar (Washington).

The data at hand indicates an occurrence across the continent in the Transitional and Canadian zones. Adults appear to be on the wing throughout the summer. Three males were bred from a "*Nematus*" larva on *Corylus* by H. G. Dyar.

#### 7. *Erromenus* (*Erromenus*) *defrictus*, new species

*Abdomen black; coxae ferruginous; second tergite of female with sparse punctures separated by about the length of their setae; ovipositor sheath rather flat, the margins convex.*

Fore wing about 5.2 mm. long; lower half of mesopleurum with medium sized punctures separated from one another by about 1.7 their diameter; hind part of mesoscutal margin elevated as a lamina about 0.35 as high as the tegula is wide; lateral carina of scutellum extending about 0.2 its length; hind tarsus somewhat shorter than in *E. marginatus*; petiolar area rather large, broadly rounded hexagonal with the top side shortened and flattened or somewhat concave, usually with two weak irregular vertical carinae; second tergite about 0.6 as long as wide, in the female polished and with sparse moderately fine punctures, the punctures separated by about the length of their setae; ovipositor sheath rather flat with the margins convex, the setiferous part about 1.0 as long as the subgenital plate. Agrees otherwise with the structural description of *E. marginatus*. The above description is from female specimens only. When the male becomes known, it may be found to have the second tergite less polished than does the female and the tarsal claws pectinate either more or less extensively than in the male of *E. marginatus*.

Hind tibia somewhat infusate apically. Otherwise colored like *E. marginatus*.

*Type:* ♀, Sligo Park near the Washington Sanitarium, Takoma Park, Md., July 23, 1943, M. Townes (Townes).

*Paratypes:* 2 ♀, taken at the type locality, June 23, 1943, and July 6, 1943, M. Townes (Townes).

The types were swept from the undergrowth of open woods.

#### 8. *Erromenus* (*Erromenus*) *glabrosus* Davis

*Erromenus glabrosus* Davis, 1897. Trans. Amer. Ent. Soc. 24: 260. Type: ♂, southern Calif. (Philadelphia).

*Lateral carina of scutellum extending 0.8 its length; wings usually smoky.*

Fore wing about 5.5 mm. long; clypeus about 2.2 as wide as long; cheek about 0.2 as long as the basal width of the mandible; mesopleurum strongly bulging just above its middle; lower half of mesopleurum with moderately fine punctures separated by about 2.0 their diameter; hind part of mesoscutal margin elevated as a lamina that is 0.55 to 0.7 as high as the tegula is wide; lateral carina of scutellum extending about 0.8 its length; tarsal claws of both sexes rather long and weakly curved, rather sparsely pectinate to near the apex; combined basal area and areola of propodeum about 1.25 as long as wide; petiolar area of moderate size, rounded hexagonal with the top side much shortened, unusually smooth and with a blunt median vertical carina; lateral section of apical carina sloping slightly upwards from the petiolar area, or horizontal; first tergite with the dorsal carinae ending 0.5 to

0.3 from its apex; second tergite about 0.57 as long as wide, strongly convex, its basal oblique grooves weak; second tergite polished and with rather fine sparse punctures; ovipositor sheath rather flat, the margins convex, its setiferous part about 0.9 as long as the subgenital plate. Agrees otherwise with the structural description of *E. marginatus*.

Black. Apical 0.75 of clypeus dark ferruginous; mandible piceous basally, yellowish medially, and ferruginous apically; palpi brown; tegula yellow, its apical third brownish; wings usually smoky (subhyaline to hyaline in the other Nearctic species); coxae piceous; trochanters brownish to ferruginous; legs beyond trochanters ferruginous, each tibia with a basal external yellow mark; hind tarsus somewhat infusate; abdomen of the female entirely ferruginous, or the extreme base of the first tergite infusate; abdomen of the male ferruginous, usually the first tergite black or piceous and the second and sometimes also the following tergites with a baso-lateral fuscous stain.

A male from Aweme, Man., has the wings subhyaline, the dorsal carina of the first tergite ending about 0.3 from the apex, and the postero-lateral part of the mesoscutal margin about 0.55 as high as the tegula is wide. All of our other specimens have the wings smoky, the dorsal carina of the first tergite ending about 0.5 from the apex, and the postero-lateral part of the mesoscutal margin about 0.7 as high as the tegula is wide. The specimen from Manitoba may represent a distinct subspecies or species.

*Specimens:* ♂, Truckee, Calif., June 19, 1927, E. P. Van Duzee (San Francisco). ♀, Colorado (Washington). ♂, Aweme, Man., May 27, 1925, R. D. Bird (Ottawa), atypical, see paragraph above. ♀, Cornucopia, 7100 ft., Ore., July 25, 1936, R. E. Rieder (Corvallis). ♂, Eagle Ridge, Klamath Lake, Ore., May 19, 1924, C. L. Fox (Townes). ♂, Seneca, Ore., July 11, 1935, Joe Schuh (Townes). ♀, Wind R., Wyo. (allotype, Philadelphia).

#### 9. *Erromenus (Erromenus) proteus*, new species

*Abdomen beyond the first tergite ferruginous; second tergite with oblique basal grooves; top side of petiolar area with a strong carina, not semi-circularly concave.*

Fore wing about 4.4 mm. long; cheek about 0.28 as long as the basal width of the mandible; lower half of mesopleurum with medium sized punctures that are separated by about 2 times their diameter; front tarsal claws of male coarsely pectinate on their basal 0.55; combined basal area and areola of propodeum about 0.9 as long as wide; petiolar area sharply hexagonal with its top side somewhat concave, without or with several ill-defined median vertical carinae or sometimes with a single strong carina; second tergite about 0.6 as long as wide, mat with the apical 0.1= subpolished, with fine to moderate sized punctures; ovipositor sheath strongly convex apically and at the margins, the rest flatter; setiferous part of ovipositor sheath about 0.8 as long as the subgenital plate. Agrees otherwise with the structural description of *E. marginatus*.

Black. Apical 0.7 of clypeus brownish ferruginous; mandible yellow, apically ferruginous; palpi brownish stramineous; tegula yellow, usually more or less brownish apically; coxae black or piceous, the front coxae often brownish ferruginous; first trochanters piceous to

ferruginous; legs beyond first trochanters ferruginous, the second trochanters and the hind tarsus more or less infuscate and each tibia with a more or less distinct basal external yellow mark; first tergite apically ferruginous; second and following tergites ferruginous, frequently with indefinite brownish areas.

The paratype males of this species are somewhat diverse in propodeal carination and abdominal sculpture. Possibly they represent more than one species.

*Type:* ♀, Paradise Valley at 4700 ft., Mt. Rainier, Wash., July 21, 1940, H. & M. Townes (Townes).

*Paratypes:* ♂, Edmonton, Alta., June 11, 1932, O. Peck (Townes). ♂, Mammoth Lakes, Calif., July 15, 1933, Bohart (Bohart). ♂, ♀, Norman Co., Minn., June 21, 1923, A. A. Nichol (St. Paul). ♀, Alpine Garden, Mt. Washington, N. H., Aug. 30, 1937, A. L. Melander (Cambridge). 2 ♂, Waskesiu Lake, Sask., July 22, 1939, A. R. Brooks (Ottawa). ♀, Washington Territory (Philadelphia).

#### 10. *Erromenus (Erromenus) dimidiatus* Cresson

Figures 13 and 16

*Tryphon dimidiatus* Cresson, 1868. Trans. Amer. Ent. Soc. 2: 108. Type: ♂, New Jersey (Philadelphia).

*Tryphon atricoxus* Walsh, 1873. Trans. Acad. Sci. St. Louis 3: 104. Type: ♀ (?), Ill. (?) (type destroyed).

*Scopiorus hiatus* Davis, 1897. Trans. Amer. Ent. Soc. 24: 258. Type: ♀, Agricultural College, Mich. (Philadelphia).

*Abdomen black basally and apically, ferruginous in the middle; upper margin of antennal socket produced.*

Fore wing about 5.8 mm. long; cheek about 0.25 as long as the basal width of the mandible; upper margin of antennal socket projecting as a flange about 0.5 as high as the scape is wide; frons strongly impressed near the antennal sockets (this is the only species of *Erromenus* known to us with the margin of the antennal socket and the frons as described above); lower half of mesopleurum with medium sized punctures separated from one another by about 1.5 their diameter; hind part of mesoscutal margin elevated as a flange about 0.35 as high as the tegula is wide; lateral carina of scutellum extending about 0.45 its length; front tarsal claws of male coarsely pectinate on their basal 0.45; combined basal area and areola of propodeum about 1.2 as long as wide; petiolar area of moderate size, hexagonal with the top and bottom sides shortened, without median vertical carinae or with two or three weak irregular ones; second tergite about 0.6 as long as wide, subpolished and rather coarsely punctate; ovipositor sheath strongly convex apically and at the margins, the rest rather flat (fig. 13); setiferous part of ovipositor sheath about 0.82 as long as the subgenital plate. Agrees otherwise with the structural description of *E. marginatus*.

Black. Apical 0.6 of clypeus brownish ferruginous; mandible more or less stained with ferruginous; palpi brown; tegula brown, yellow antero-laterally; trochanters reddish piceous to black; legs beyond trochanters ferruginous, each tibia with an external basal yellow mark; first tergite apically in the middle ferruginous; second, third, and usually also the fourth tergites ferruginous; fifth and following tergites

black or sometimes stained with ferruginous, their apical margins ferruginous.

*Specimens:* Many males and females from ALASKA (Curry and Matanuska); ALBERTA (Banff, Bilby, Edmonton, and Wabamun); BRITISH COLUMBIA (Carbonate on the Columbia River at 2600 ft. and Howser in the Selkirk Mts.); CALIFORNIA (Coffee Creek at Big Flat in Tuolumne Co.); COLORADO; CONNECTICUT (Hartford); IDAHO (Juliaetta); KANSAS (Lawrence); MAINE (Bar Harbor, Medomak, and Narrows on Mt. Desert Island); MANITOBA (Aweme and The Pas); MASSACHUSETTS (Amherst, Brookline, Dorchester, Gloucester, Milton, South Hadley, and Wellesley); MICHIGAN (Agricultural College, Cedar River, Cheboygan Co., and Missaukee Co.); MINNESOTA (Carlton, Fridley Sand Dunes in Anoka Co., Itasca Park, Grand Rapids, and Ramsey Co.); NEW BRUNSWICK (Frederickton); NEW HAMPSHIRE (Glen House, Hanover, Jaffrey, and Pinkham Notch); NEW YORK (Ava, Danby, Horton, Homer, Ithaca, Lancaster, Long Island, McLean, Oswego, Peru, Rock City in Cattaraugus Co., Saranac Lake, Speculator, Syracuse, Taughannock Falls, Utica, and West Nyack); NOVA SCOTIA (Baddeck, South Milford, and Truro); ONTARIO (Constance Bay and Sudbury); OREGON (near Headquarters of Crater Lake Park at 6600 ft.); PENNSYLVANIA (Harrisburg, North Cumberland, Spring Brook, Swarthmore, and West Newton); QUEBEC (Aylmer, Brome, Georgeville, Joliette, Knowlton, Lanoraie, Montreal, St. Annes', St. Johns, and Sweetsburg); SASKATCHEWAN (Prince Albert National Park); VERMONT (Bennington and Lake Willoughby); and WASHINGTON (Mt. Baker, and Mt. Rainier at 4700 ft, 5300 ft., and 5500 ft.).

This is the commonest Nearctic *Erromenus*. It occurs in the Transitional, Canadian, and Hudsonian zones across the continent. At Spring Brook, Pa., a populous colony was found in grass along a roadside and it appears likely that grassy places are the normal habitat. Most species of *Erromenus* occur among shrubs. Adults are on the wing in mid-spring, reach a peak of abundance in late spring or early summer, and disappear about the middle of the summer, or somewhat later in more northern localities. A single generation a year is indicated by this seasonal distribution. Early and late collecting dates of interest are April 20 in Douglas Co., Kansas; May 7 at Spring Brook, Pa.; May 15 at South Hadley, Mass.; May 22 at North Cumberland, Pa.; May 27 at Brookline and at Wellesley, Mass.; May 29 in Missaukee Co., Mich.; May 30 at Syracuse, N. Y.; May 31 at Brome, Que.; July 26 at Horton, N. Y.; Aug. 8 on Montreal Island, Que.; Aug. 11 in Cheboygan Co., Mich.; Aug. 17 at 5300 ft. on Mt. Rainier, Wash.; Aug. 20 at Edmonton, Alta.; and Aug. 26 at Cedar River, Mich.

#### 11. *Erromenus (Erromenus) unguatus*, new species

Figure 15

*Areolet* absent; *mesopleurum* very weakly and sparsely punctate; *ovipositor* sheath about 1.05 as long as the first tergite.

Fore wing about 4.2 mm. long; face most strongly bulging just below the antennal sockets, medially with rather coarse sharp punctures, sublaterally with punctures finer and denser, and laterally with punctures fine and sparse; clypeus about 2.5 as wide as long, convex

transversely and convex longitudinally but with a flattening centered just beyond the middle; central 0.5 of apical margin of clypeus very weakly convex; clypeal suture a furrow, deepened at the foveae into well-marked somewhat elongate pits that are much narrower than the basal diameter of the apical flagellar segment; cheek about 0.22 as long as the basal width of the mandible; occipital carina complete, strong at its juncture with the hypostomal carina; lower half of mesopleurum with fine sparse punctures separated by more than 3 times their diameter; postero-lateral margin of mesoscutum elevated as a lamina that is about 0.2 as high as the tegula is wide; lateral carina of scutellum extending about 0.3 its length; areolet absent; flagellar segments, tarsi, and femora unusually short, the hind femur about 0.73 as long as the hind tibia; front tarsal claws of male sparsely pectinate on the basal 0.75, of the female rather densely pectinate to near the apex; combined basal area and areola of propodeum about 0.9 as long as wide; petiolar area large, sharply hexagonal with its upper side somewhat shortened and more or less concave, without a median vertical carina; lateral section of apical carina horizontal, very short; dorsal carinae of first tergite sharp and rather strong, ending about 0.18 from the apex of the tergite; second tergite about 0.5 as long as wide, without distinct oblique basal furrows, very finely punctate and more or less mat and longitudinally rugulose to subpolished with the apical 0.2 polished; sixth and seventh tergites each projecting far beyond the preceding tergite, the seventh of the female very deep and obliquely placed so as to accommodate the exceptionally long ovipositor, but otherwise unspecialized; ovipositor sheath very long, tapering gradually from the base to the blunt apex, more strongly curved basally than apically, roundly convex in cross section, the setiferous part of the sheath about 2.7 as long as the subgenital plate and 1.05 as long as the first tergite (fig. 15).

**Black.** Clypeus, mandible, and usually the under side of scape and pedicel fulvous, the basal 0.25± of the clypeus dark brown; palpi pale ferruginous; flagellum usually somewhat stained with fulvous, especially beneath; tegula pale ferruginous; legs ferruginous, rarely the coxae somewhat infuscate; apical 0.2 of first tergite and all of the following tergites ferruginous, rarely the first tergite almost entirely black or piceous and the apical tergites somewhat infuscate.

**Type:** ♀, Ithaca, N. Y., May 29, 1934, H. Townes (Townes).

**Paratypes:** ♀, McLean Reserve, Tompkins Co., N. Y., May 22, 1937, H. Townes (Townes). ♀, Six Mile Creek Valley, Ithaca, N. Y., June 15, 1935, P. P. Babiý (Townes). ♂, Pisgah Mt. at 4800 to 5300 ft., N. C., June 21, 1940, H. & M. Townes (Townes). ♀, Niagara Glen, Ont., June 10, 1926, G. S. Walley (Ottawa). ♂, Mt. Rainier at 4200 ft., Wash., July 15, 1940, H. & M. Townes (Townes). ♀, Mt. Rainier at 5300 ft., Wash., Aug. 16, 1940, H. & M. Townes (Townes).

## 12. *Erromenus (Erromenus) planus*, new species

Figure 19

*Clypeal foveae very large; seventh tergite of female with a median, apical flat, down-sloping area bearing erect setae; male not easily distinguished from that of E. caelator or of E. nasalis.*

Fore wing about 4.5 mm. long; seventh tergite of female with a large medio-apical flat area sloping downwards towards the apex of the tergite and bearing rather long erect setae (fig. 19), the apical margin of the tergite unspecialized (fig. 19A); ovipositor sheath about 0.75 as long as the subgenital plate (fig. 19). Agrees otherwise with the structural description of *E. caelator*.

Black. Mandible ferruginous; clypeus and palpi pale ferruginous, the basal 0.35 = of the clypeus black; scape usually fulvous beneath; tegula yellow, postero-mesally pale ferruginous to brownish; legs ferruginous, rarely the hind and middle coxae piceous and the front coxae and basal trochanters somewhat infusate; tibiae each with an external basal yellow mark; apical 0.2 to 0.35 of first tergite and all of the following tergites ferruginous.

*Type:* ♀, about 5 miles north of Troy, N. Y., Sept. 2, 1934, H. Townes (Townes).

*Paratypes:* ♀, Edmonton, Alta., July 2, 1945, E. H. Strickland (Townes). ♀, British Columbia, 1939 (Townes). ♀, Felton at 300 to 500 ft., Santa Cruz Mts., Calif., May 15 to 19, 1907, J. C. Bradley (Ithaca). ♂, Felton at 300 to 500 ft., Santa Cruz Mts., Calif., May 20 to 25, 1907, J. C. Bradley (Ithaca). ♂, Poughkeepsie, N. Y., Aug. 11, 1936, H. Townes (Townes). ♀, Prince Albert National Park, Sask., July 20, 1941, J. G. Rempel (Townes). Since males of this species do not possess good diagnostic characters, the true identity of the two male paratypes is open to question.

### 13. *Erromenus (Erromenus) caelator*, new species

Figure 20

*Clypeal foveae very large; seventh tergite of female with an apical, downcurved, chisel-like tooth; male not easily distinguished from that of E. nasalis or of E. planus.*

Fore wing about 4.6 mm. long; face most strongly bulging just below the antennal sockets, medially with large indistinct punctures that are somewhat confluent, laterally almost impunctate; clypeus about 2.1 as wide as long, convex transversely and convex longitudinally but with a flattening centered just below the middle; clypeal suture a furrow, deepened at the foveae into a pair of large deep pits slightly larger than the basal diameter of the apical flagellar segment, the pits partially obscured by setae; cheek about 0.5 as long as the basal width of the mandible; occipital carina reaching the hypostomal carina, strong and sharp at its juncture; lower half of mesopleurum with medium sized punctures separated by about 1.4 their diameter; hind part of mesoscutal margin elevated as a lamina about 0.3 as high as the tegula is wide; lateral carina of scutellum extending about 0.45 its length; areolet present; front tarsal claws of male sparsely pectinate on their basal 0.7, of the female with moderately dense pectination on their basal 0.75; combined basal area and areola of propodeum about 0.9 as long as wide; petiolar area of moderate size, subcircular to roundly hexagonal, usually longer than broad, the top side more or less concave, without or sometimes with a median vertical carina; lateral section of apical carina horizontal; second tergite about 0.6 as long as wide, polished or somewhat mat, rather coarsely punctate; female with the

sixth and seventh tergites each projecting a little beyond the preceding tergite, the seventh tergite decurved apically and with a median apical chisel-like projecting tooth (figs. 20 and 20A); ovipositor sheath about 1.1 as long as the subgenital plate, finger-like, convex, evenly upcurved, and tapered to its bluntly pointed apex (fig. 20).

Black. Mandible ferruginous, slightly infusate basally; clypeus and palpi pale ferruginous, the basal  $0.35 \pm$  of the clypeus black; tegula yellow, postero-mesally brownish ferruginous; legs ferruginous, the hind coxae piceous, the middle coxae ferruginous piceous, and the front coxae and basal trochanters more or less infusate ferruginous; tibiae each with a basal external yellow mark; apical 0.1 to 0.3 of first tergite and all of the following tergites ferruginous.

*Type*: ♀, Ithaca, N. Y., May 30, 1937, H. Townes (Townes).

*Paratypes*: ♀, Saranac Lake, N. Y., June 20, 1946, R. T. Mitchell (Mitchell). ♀, Foxborough, Ont., Sept. 9, 1934, H. G. James (Ottawa). ♀, Swansea, near Toronto, Ont., July 12, 1938, H. S. Parish (Townes). ♀, Swansea near Toronto, Ont., July 30, 1938, H. S. Parish (Townes). ♀, Thunder Bay Beach, Ont., May 29, 1939, H. S. Parish (Townes).

#### 14. *Erromenus (Erromenus) nasalis*, new species

Figure 21

*Clypeal foveae very large; seventh tergite of female with an apical, rounded, nose-like prominence that is covered with erect setae; male not easily distinguished from that of E. caelator or of E. planus.*

Fore wing about 4.6 mm. long; second tergite rather coarsely punctate, mat with the apical 0.15 polished or sometimes the entire tergite more or less polished; seventh tergite of female apically much decurved and with a median apical nose-like hump that is covered with rather long upright setae (figs. 21 and 21A); ovipositor sheath about 0.8 as long as the subgenital plate (fig. 21). Agrees otherwise with the structural description of *E. caelator*.

Black. Mandible ferruginous, usually yellow medially; clypeus and palpi pale ferruginous, the basal  $0.35 \pm$  of the clypeus black; scape usually fulvous beneath; tegula yellow, postero-mesally pale ferruginous to brownish; legs ferruginous, the coxae and basal trochanters frequently black, piceous, or infusate; tibiae each with a basal external yellow mark; apical 0.12 to 0.25 of first tergite and all of the following tergites ferruginous, in the males the second and third tergites sometimes with median basal infusate areas and the apical tergites sometimes somewhat infusate baso-laterally.

*Type*: ♀, just above Narada Falls (4700 ft.), Mt. Rainier, Wash., July 19, 1940, H. & M. Townes (Townes).

*Paratypes*: 7 ♂, ♀, collected with the type (Townes and Lawrence). ♀, Estes Park, Colo., July 11, 1934, A. L. Melander (Cambridge). ♂, Mt. Madison, N. H., June 24, 1938, H. & M. Townes (Townes). ♂, Connecticut Hill at 2095 ft., Tompkins Co., N. Y., June, 1937 (Townes). ♀, Millwood, N. Y., June 21, 1936, H. K. Townes (Townes). ♂, Poughkeepsie, N. Y., Aug. 20, 1936, H. K. Townes (Townes). ♀, Franklin Co., Ohio, Sept. 12, 1941, J. E. Gillaspay (Washington). ♀, Laneil, Que., July 13, 1932, H. S. Fleming (Ottawa). ♀, Alton, R. I., Sept. 18, 1937, M. Townes (Townes). ♀, Westerly, R. I., June 10,



1936, M. Townes (Townes). ♀, Westerly, R. I., June 27, 1946, M. Townes (Townes). 4 ♂, 7 ♀, Mt. Rainier, Wash., at 3800 ft., 4000 ft., 4200 ft., 4700 ft., and 5000 ft., July 7 to 22, 1940, H. & M. Townes (Townes). Since the males lack good diagnostic characters it is possible that some of the male paratypes are not correctly determined.

This species occurs across the continent in the Transitional, Canadian, and Hudsonian zones. The capture of specimens in Rhode Island from June 10 to September 18 indicates more than one generation a season.

#### 15. *Erromenus* (*Erromenus*) *labratus*, new species

*Face and clypeus very broad and nearly flat, the clypeus about 2.7 as wide as long; hind femur ferruginous.*

Type female: Fore wing 5.2 mm. long; clypeus 2.7 as wide as long; cheek 0.12 as long as the basal width of the mandible; lower half of mesopleurum with moderately fine punctures separated by about 1.2 their diameter; front tarsal claws sparsely pectinate on their basal 0.3; combined basal area and areola 0.75 as long as wide; second tergite 0.6 as long as wide, with rather close medium sized punctures separated by about 1.2 their diameter. Agrees otherwise with the structural description of *E. tonto*.

Black. Clypeus light ferruginous, its basal 0.35 black; mandible and palpi yellow; apical part of scape fulvous below; tegula yellow, postero-mesally stained with ferruginous; legs ferruginous; front coxae brownish ferruginous basally, the rest yellow; middle coxa light brown basally, the rest yellow; hind coxa black, ferruginous apically and below; trochanters and apices of femora yellow; front and middle tibiae and tarsi very pale ferruginous; bases of all tibiae yellow; hind tibia and segments of hind tarsus brownish ferruginous, pale basally; apical margin of second to fourth tergites, apical 0.3 of fifth and all of following tergites, genitalia, and subgenital plate stramineous or pale fulvous.

*Type:* ♀, G. Alpine Cr., Tahoe, Calif., July 5, 1915, E. P. VanDuzee (Berkeley).

#### 16. *Erromenus* (*Erromenus*) *tonto*, new species

*Face and clypeus very broad and unusually flat, the clypeus about 3.0 as wide as long; hind femur black.*

Fore wing about 5.5 mm. long; face rather weakly convex, medially with rather coarse punctures, sublaterally the punctures finer and dense, and laterally the punctures fine and sparser. Clypeus about 3.0 as wide as long, very weakly convex transversely, longitudinally convex in its basal 0.3 and the rest of its length flat; clypeal suture a furrow, deepened into a pair of small pits at the foveae; cheek about 0.14 as long as the basal width of the mandible; occipital carina reaching the hypostomal carina, strong and sharp at its juncture; lower half of mesopleurum with moderately fine punctures separated by about 1.4 their diameter; areolet present; front tarsal claws of male pectinate on their basal 0.25, of female the pectinations not clearly visible in the unique specimen at hand, but the claws apparently pectinate on their basal 0.3; combined basal area and areola of propodeum about 0.85 as

long as wide; petiolar area of moderate size, hexagonal, unusually smooth and usually with a weak median vertical carina; lateral section of apical carina unusually long, sloping slightly upwards from the petiolar area; second tergite of male about 0.77 as long as wide, of female 0.67 as long as wide; second tergite with rather fine punctures separated by about 1.5 their diameter; female with the sixth and seventh tergites telescoped within the fifth, the median half of the apical margin of the fifth tergite membranous, and the apical margin of the sixth and seventh tergites with short ventrally-projecting setae; ovipositor sheath almost flat, polished, about 1.0 as long as the subgenital plate. Agrees otherwise with the structural description of *E. variolae*.

Black. Clypeus light ferruginous, its basal 0.35 black; mandible white, black at the extreme base and dark ferruginous apically; palpi and tegula white; legs black, whitish as follows: lower part of front and middle coxae, first trochanters of front and middle legs except behind, second trochanters of front and middle legs, apex of first trochanter and more or less of second trochanter of hind leg, bases and apices of femora, ends and outer part of fore and middle tibiae, tibial spurs, and fore and middle tarsi, the middle tarsus often brownish apically; female with seventh tergite, ovipositor sheath, and subgenital plate light ferruginous; male with apical part of eighth tergite and of claspers more or less whitish.

*Type*: ♀, headquarters area of the Sierra Ancha Experimental Forest, Parker Creek, Sierra Ancha, Ariz., 5400 ft., April 24, 1947, H. & M. Townes (Townes).

*Paratypes*: 11 ♂, taken at the type locality by H. & M. Townes on April 19, 21, 24, 25, 26, 29, and May 2 and 7, 1947 (Townes). 13 ♂, Pocket Creek, Sierra Ancha, Ariz., May 5, 1947, H. & M. Townes (Townes). 6 ♂, Workman Creek, Sierra Ancha, Ariz., April 30, May 6 and 8, 1947, H. & M. Townes (Townes).<sup>4</sup>

This species seemed common among deciduous trees along the streams of the Tonto National Forest area at 5300 to 6200 ft. elevation.

### 17. *Erromenus (Erromenus) dolichops*, new species

Figure 18

*Areolet absent; cheek about 0.6 as long as the basal width of the mandible; occipital carina not reaching the hypostomal carina, or weak at its juncture with the hypostomal carina.*

Fore wing 4.8 mm. long; face longer than in other Nearctic species of the genus, medially with large indistinct punctures that are somewhat confluent, laterally almost impunctate; clypeus about 2.0 as long as wide, transversely strongly convex, longitudinally convex with a weak flattening beyond the middle; clypeal suture a broad furrow; clypeal foveae large and pit-like; cheek about 0.6 as long as the basal width of the mandible; lower half of mesopleurum with medium sized punctures separated by about 1.2 their diameter; lateral carina of

<sup>4</sup>These specimens are part of a lot of about 8,000 ichneumonids collected by the authors in Arizona with the aid of a grant from the Penrose Fund of the American Philosophical Society. Other Tryphonini in this lot of specimens are *Polyblastus tibialis*, *P. pedalis*, *Erromenus dolichops*, *Monoblastus montezuma* and *M. kaniacensis*.

scutellum extending 0.2 to 0.6 its length; areolet absent; petiolar area longer than wide, elliptical or somewhat elongate hexagonal; second tergite about 0.75 as long as wide, mat and rather coarsely punctate basally, subpolished and more finely punctate apically; apical tergites of female retracted and ovipositor sheath flat (fig. 18) as in *E. variolae*; apex of sixth and seventh tergites with moderately long ventrally-projecting setae. Agrees otherwise with the structural description of *E. variolae*.

Black. Clypeus and mandible dark ferruginous, the basal  $0.3 \pm$  of the clypeus black and the basal 0.2 to 0.6 of the mandible black or infusate; palpi light brown or ferruginous to dark brown; tegula light to dark ferruginous; legs dark ferruginous, the coxae and trochanters typically black, but frequently more or less ferruginous; hind tarsus and apical part of fore and middle tarsi infusate; hind tibia usually weakly infusate apically and basally; abdomen varying from entirely ferruginous beyond the first tergite with the apical 0.12 of the first tergite ferruginous to mostly black, but with broad to very broad apical ferruginous margins on the second and following tergites, more or less continued forward along the sides. Frequently the tergites beyond the first are ferruginous with a large median basal semicircular black area.

There is a female from North Saugus, Mass., with the scape and pedicel fulvous and the flagellum strongly tinged with fulvous. Three males from Takoma Park and Bowie, Maryland, have the coxae and trochanters entirely ferruginous. A specimen from Gull Lake, Alta., one from Stoneham, Que., and three reared specimens from Abington, Conn., have the trochanters and coxae ferruginous but the coxae infusate or black basally.

*Type*: ♀, just above Narada Falls (4700 ft.), Mt. Rainier, Wash., Aug. 17, 1940, H. & M. Townes (Townes).

*Paratypes*: ♀, taken with the type (Townes). ♂, ♀, Mt. McKinley National Park, Alaska, 1932, F. W. Morand (Washington and Townes). ♀, Gull Lake, Alta., June 14, 1929, E. H. Strickland (Townes). ♀, Oak Creek Canyon, Ariz., May 17, 1947, H. & M. Townes (Townes). ♂, Agassiz, B. C., July 6, 1927, H. H. Ross (Ottawa). ♂, Canal Flats, B. C., emerged Aug. 23, 1939, reared from "green tapered sawfly larva on *Larix occid.*," J. L. Johnson (Ottawa). ♂, ♀, Cranbrook, B. C., emerged July 26, 1939, reared from sawfly, C. Bloom (Ottawa). ♂, Cranbrook, B. C., emerged Sept., 1939, reared from sawfly, C. Bloom (Ottawa). ♀, Gold Creek, Cranbrook, B. C., emerged Aug. 7, 1939, from a small sawfly cocoon on *Larix*, F. H. Pym (Ottawa). 2 ♂, ♀, Abington, Conn., "5-9-21," reared from a tenthredinid (Washington and Townes). ♂, Churchill, Man., July 14, 1937, W. J. Brown (Ottawa). ♂, Bowie, Md., Oct. 9, 1943, H. & M. Townes (Townes). 2 ♂, Takoma Park, Md., Sept. 22, 1945, H. & M. Townes (Townes). ♂, Takoma Park, Md., Oct. 13, 1945, H. & M. Townes (Townes). ♀, Takoma Park, Md., Oct. 26, 1946, H. & M. Townes (Townes). ♀, North Saugus, Mass., May 25, 1907 (Townes). ♂, Oswego, N. Y., July 7, 1936 (Washington). ♂, 3 ♀, Jockvale, Ont., May 28, 1934, G. S. Walley (Ottawa). ♂, 2 ♀, Jockvale, Ont., June 1, 1935, "flying about green sawfly larva on aspen," G. S. Walley (Ottawa). ♀, Stoneham, Que., June 18, 1938, H. & M. Townes (Townes). ♂,

Prince Albert National Park, Sask., July 19, 1941, J. G. Rempel (Townes). ♂, Northbend, King Co., Wash., July 8, 1920, E. P. VanDuzee (San Francisco). 9 ♂, Mt. Rainier at 5300 ft., Wash., Aug. 15 and 17, 1940, H. & M. Townes (Townes and Lawrence). ♂, Westport, Wash., July 17, 1940, H. & M. Townes (Townes).

This species ranges across the continent in the Transitional, Canadian, and Hudsonian zones. It occurs among shrubs where it appears to be parasitic on a variety of Tenthredinidae. Adults are on the wing from spring to well into the fall, indicating several generations a season.

#### 18. *Erromenus (Erromenus) variolae*, new species

*Clypeal suture absent; clypeus flat in profile; hind femur infusate to blackish; occipital carina not reaching the hypostomal carina, or weak at its juncture with the hypostomal carina.*

Fore wing about 4.8 mm. long; face rather evenly convex, most protuberant just below the antennal sockets, medially with deep coarse confluent punctures, sublaterally with punctures somewhat smaller and not confluent, laterally with a few weak punctures; clypeus about 2.5 as wide as long, transversely convex and longitudinally flat; clypeal suture not distinctly indicated between the foveae, the clypeus medially separated from the face only by its practical lack of punctation; clypeal foveae large and pit-like; cheek about 0.3 as long as the basal width of the mandible; occipital carina not quite reaching the hypostomal carina, or if reaching it weak or indistinct at the juncture; lower half of mesopleurum with medium sized punctures separated by about 1.0 their diameter; hind part of mesoscutal margin elevated as a lamina about 0.3 as high as the tegula is wide; lateral carina of the scutellum extending about 0.3 its length; areolet usually present (present in the type and in two of the three paratypes); front tarsal claws sparsely pectinate on the basal 0.45 in the male and on the basal 0.65 in the female; combined basal area and areola of the propodeum about 1.1 as long as wide; petiolar area rather small, somewhat longer than wide, roundly hexagonal with its top side flattened or somewhat concave, without or with a weak incomplete median vertical carina; lateral section of apical carina unusually long and sloping upwards from the petiolar area; dorsal carinae of first tergite sharp and strong, ending 0.15 to 0.25 from the apex of the tergite; second tergite about 0.78 as long as wide, polished, with close medium sized punctures basally and more distant finer punctures apically; in the female the sixth tergite projecting little if any beyond the fifth, the seventh tergite capable of being completely retracted within the sixth so that only its apical margin is visible and the apex of the abdomen is hollowed out and lined mostly with inter-segmental membrane (as in *E. dolichops*, fig. 18); apex of sixth and seventh tergites with very long, curved, ventrally projecting setae; ovipositor sheath about 0.8 as long as the subgenital plate, broad, flat, elliptical but somewhat upcurved (as in *E. dolichops*, fig. 18).

Black. Apical 0.65 of clypeus pale ferruginous; apical 0.4 to 0.65 of mandible dark ferruginous; palpi pale ferruginous; under side of scape and flagellum more or less ferruginous; tegula yellow, mesally stained.

with ferruginous; fore coxa infusate ferruginous, paler apically; middle coxa piceous; hind coxa black; basal hind trochanter brownish ferruginous; apices of fore and middle femora and a basal section of all tibiae pale yellow; hind femur pale brown to blackish, pale at the base and apex; hind tibia infusate except basally, darkest towards its apex; hind tarsus fuscous; the rest of the legs ferruginous; first tergite medially and second and third tergites except laterally with the apical margins narrowly fulvous.

*Type*: ♂, Lawrence, Kans., May 23, 1941, H. Townes (Townes).

*Paratypes*: ♂, Chesilhurst, N. J., June 3, 1939, H. Townes (Townes). ♂, Ithaca, N. Y., May 15, 1936 (Townes). ♀, Dixie Landing, Va., May 27, C. L. Marlatt (Washington).

The specimen from Chesilhurst, N. J., was collected among scrub oak and *Vaccinium* bushes.

### Subgenus *Aderaeon*, new subgenus

Figure 17

*Type*: *Erromenus bedardi* as identified here.

Clypeus with its lateral apical parts weakly impressed, otherwise rather flat; epomia short, weak, and indistinct, not extending below the pronotal sulcus; anterior half of subtegular ridge somewhat concave and distant from the tegula, the ridge capable of touching the tegula only at its middle (fig. 17); tarsal claws apparently not pectinate; basal angles of first tergite very strong; sixth and seventh tergites of female long, each projecting strongly beyond the preceding tergite; subgenital plate of female very long; ovipositor sheath without setae, very small, about 0.3 as long as the subgenital plate.

This subgenus contains only one species, described below.

### 19. *Erromenus* (*Aderaeon*) *bedardi* Provancher, new combination

Figure 17

*Erromenus Bedardi* Provancher, 1879. Nat. Canad. 11: 266; Faune, p. 424. *Type*: ♀, Douglastown, Que. (Quebec).

Fore wing about 6.0 mm. long; face somewhat convex, bulging just below the antennal sockets, its punctation dense and rather coarse medially, somewhat sparser and finer near the sides; clypeus about 2.2 as wide as long, transversely weakly convex, longitudinally very weakly convex, its lateral apical areas somewhat impressed; clypeal suture a furrow; clypeal foveae rather large abrupt pits; cheek about 0.5 as long as the basal width of the mandible; occipital carina reaching the hypostomal carina, strong and sharp at the juncture; lower half of mesopleurum with moderately fine punctures separated by about 1.2 times their diameter; hind part of mesoscutal margin elevated as a lamina about 0.25 as high as the tegula is wide; scutellum with lateral carinae only at its basal corners; areolet lacking; combined basal area and areola of propodeum about 0.8 as long as wide; petiolar area large, angularly hexagonal, the upper side broadened and more or less concave, without a median vertical carina; lateral section of apical carina rather long, horizontal; dorsal carinae of first tergite exceptionally high and heavy, ending at the apex of the tergite and continued weakly on to the

basal 0.4 of the second tergite as lateral margins of a median subbasal swelling; second tergite about 0.6 as long as wide, with a pair of broad weak oblique furrows that demark its lateral basal corners to slightly beyond the level of the spiracles, entirely densely and strongly rugulose and mat; ovipositor sheath very small, slender, weakly upcurved, and tapered evenly to its sharp slender apex.

Black. Mandible and tegular dark ferruginous; apical 0.7 of clypeus, the palpi, and the legs ferruginous; under side of scape often more or less ferruginous.

*Specimens:* ♀, McLeod Meadow, Kootenay Park, B. C., reared from *Pikonema* sp., July 17, 1936, H. Richmond (Ottawa). ♀, Gloucester, N. B., reared from *Pikonema dimmockii*, April 17, 1939 (Ottawa). ♀, Madawaska Co., N. B., reared from *Pikonema alaskensis*, Feb. 27, 1940 (Ottawa). ♀, Northumberland Co., N. B., reared from *Pikonema alaskensis*, Mar. 17, 1941 (Ottawa). ♂, Halifax Co., N. S., reared from *Pikonema alaskensis*, Mar. 20, 1941 (Ottawa). ♀, Franz, Ont., reared from *Pikonema alaskensis*, April 5, 1939 (Ottawa). ♀, Grant, Ont., reared from *Pikonema dimmockii*, Mar. 3, 1938 (Ottawa). ♀, Heron Bay, Ont., reared from *Pikonema dimmockii*, April 2, 1939 (Ottawa). ♀, Massey, Ont., reared from *Pikonema alaskensis*, Mar. 31, 1939 (Ottawa). ♀, North Bay, Ont., reared from *Pikonema dimmockii*, Mar. 6, 1938 (Ottawa). ♀, Skead, Ont., reared from *Pikonema dimmockii*, Mar. 7, 1938 (Ottawa). ♀, Swastika, Ont., reared from *Pikonema dimmockii*, Mar. 7, 1938 (Ottawa). ♂, Canton Albert, Que., reared from *Pikonema dimmockii*, June 2, 1941 (Ottawa). 4 ♂, 2 ♀, Cascapedia River, Que., reared July 1 to 15, 1935, M. L. Prebble (Ottawa and Washington). ♂, Gracefield, Que., June 10, 1937, O. Peck (Ottawa). ♂, Riv. aux Outardes, Que., reared from *Pikonema dimmockii*, Feb. 2, 1941 (Ottawa). ♀, St. Raymond, Que., reared from *Pikonema alaskensis*, Mar. 29, 1939 (Ottawa). ♀, Wright, Que., June 29, 1935, G. S. Walley (Ottawa). ♂, Que., incubator reared from *Pikonema dimmockii* (Ottawa). ♀, reared from *Pikonema dimmockii*, Feb. 22, 1937 (Ottawa).

This species appears to occur in the Canadian Zone from the Atlantic to the Pacific. Rearing records indicate it to be parasitic exclusively upon species of *Pikonema*, a genus of Tenthredinidae restricted to *Picea*. Only two individuals among those reported above were collected in the wild, taken at Gracefield and Wright, Que., on June 10 and June 29, respectively. Seven reared specimens emerged from July 1 to July 15, probably during a natural emergence period. The other emergences, all in February, March, and April, were doubtless affected by a laboratory climate.

## BOOK NOTICE

THE BLOWFLIES OF NORTH AMERICA, by DAVID G. HALL. 477 pages.

Numerous illustrations. Price, \$6.50. The Thomas Say Foundation.

Send orders to Professor J. J. Davis, Purdue University, Lafayette, Indiana.

Seldom does a book command the respect and admiration which this one elicits. It is obviously the result of labor of love over a long period of years and this labor has resulted in useful information often needed by entomologists and others concerned with the health of man, domesticated animals, and wildlife. This information consists of keys for the identification of North American blowflies and knowledge of their classification, life histories, habits, geographic distribution, and control. So much new material appears for the first time that this reference book is necessary if one has to deal with the subject it treats.

The systematic account of the Calliphoridae of North America includes all known species which total 83 in 27 genera. Fifteen of these species and 6 genera are described as new. There are, as could be expected, many new combinations of names; thus the screwworm fly becomes *Callitroga americana* and the secondary screwworm fly *Callitroga macellaria* (apparently the recognition of an old combination), and *Lucilia sericata* becomes *Phaenicia sericata*. It is surprising to learn that *Lucilia caesar* has apparently never been taken in North America and what American entomologists have called by that name is usually *Lucilia illustris* (Meigen). The bird nest screwworm flies are placed in a new genus, *Apaolina*. Changes in names are deplored by those of us who have to learn the new names but there appears to be no other way to correct errors and to arrive at a better understanding of classification.

The abundance of keys and the detailed descriptions are rivaled by the splendid illustrations. Dr. Hall is well known as an illustrator of insects. There are five colored plates, each of an adult fly, nine figures in the text mainly of internal anatomy of adults and examples of myiasis, and forty-six plates each having several figures of heads and genitalia of adults or cephaloskeletons and spiracles of larvae. The detailed illustrations of larvae are particularly welcome and are worth the price of the book for anyone having to identify maggots in this family. There are twelve pages of references and an index of eleven pages.

A contribution of this order is regularly an impetus to additional studies. In this connection it is of interest that the author points out that there are probably many species to be discovered and that the biologies and immature stages of a majority of the species remain to be discovered.

The binding and printing is of excellent quality.—C. VENARD.

"The Blowflies of North America" is truly a work of love. As a student and a companion in the field we have known David G. Hall from his initiation into entomology by James Hine (Daddy Hine). Hall started out as a student of art in Cleveland. He was fascinated by insects. On a week-end trip he collected across Professor Hine's fruit farm in the Cleveland district. Hine recognized the intense interests of his trespasser and suggested that he study entomology at Ohio State University. Hine fascinated Hall and Hall worshipped Hine, who had opened the double door to emotional art and exacting science. A devotee had been recognized and reclaimed. Hall's father was a successful minister. We have known other eminent biologists who were natural artists, honest clear-minded scientists and who were fortunate enough to have been guided mentally by a sincere, religious father. Luck was with Hall from birth. Hine gave Hall the opening and early guidance. Later Aldrich gave Hall every assistance available. Such is the continuing guidance of good teachers down through time.

"The Blowflies of North America" is a work of love! Its exacting standards on every page of print and in every illustration, a work of many years, show it to be outside of and above any thought of lengthy personal bibliography or elevation in rank and salary.

Professor Venard has generously helped us with a technical diagnosis. We do not know Diptera beyond the bloody attacks of *Chrysops*, double chins from black flies and the irritating punctures of mosquitoes.—C. H. KENNEDY.

ANNALS  
OF  
The Entomological Society of America

Volume XLII

DECEMBER, 1949

No. 4

A REVISION OF THE GENERA AND OF THE AMERICAN  
SPECIES OF TRYPHONINI

(Hymenoptera: Ichneumonidae)

PART II<sup>1</sup>

HENRY K. TOWNES AND MARJORIE C. TOWNES,  
State College, Raleigh, North Carolina

Genus *Monoblastus*

Figures 22 to 31

- Monoblastus* Hartig, 1837. Wieg. Arch. Naturg. 3: 155. Type: *Monoblastus caudatus* Hartig. Designated by Viereck 1914.
- Otoblastus* Foerster, 1868. Verh. Naturh. Ver. Preuss. Rheinlande. 25: 201. New synonymy. Type: *Tryphon luteomarginatus* Gravenhorst. Included by Thomson 1883.
- Coeloconus* Foerster, 1868. Verh. Naturh. Ver. Preuss. Rheinlande, 25: 203. New synonymy. Type: *Ichneumon brachyacanthus* Gmelin. Included by Morley 1912.
- Neleges* Foerster, 1868. Verh. Naturh. Ver. Preuss. Rheinlande, 25: 204. New synonymy. Type: *Tryphon proditor* Gravenhorst. Included by Pfankuch 1907.
- Catocentrus* Walsh, 1873. Trans. St. Louis Acad. Sci. 3: 89. New synonymy. Type: *Tryphon philanthoides* Cresson. Monobasic.
- Anelpistus* Brauns, 1898. Arch. Ver. Freunde Naturg. Mecklenburg 51: 60. New synonymy; preoccupied by Horn 1870. Type: (*Anelpistus bidentatus* Brauns) = *proditor* Gravenhorst. Monobasic.
- Braunsianus* Berg, 1898. Comunic. Mus. Buenos Aires 1: 42. New name for *Anelpistus* Brauns.
- Idothrichus* Schmiedeknecht, 1907. Hymen. Mittelur., p. 619. New synonymy. Type: *Phaestus sericeus* Brischke. Monobasic.

*Ovipositor sheath usually long and narrow; posterior mandibular condyles wider apart than are the eyes; second recurrent vein not strongly zigzagged.*

Fore wing 4.0 to 7.5 mm. long; body stout to rather slender; clypeus broad, with basal and apical sections meeting in a submedian transverse ridge to evenly convex, the apical margin with a fringe of unspecialized setae; cheek 0.1 to 0.3 as long as the basal width of the mandible; posterior mandibular condyles separated from each other by a distance equal to, or usually greater than that between the eyes at the level of the clypeal foveae; outer face of mandible at its basal 0.2 approxi-

<sup>1</sup>Part I of this paper was published in the Annals of the Entomological Society of America, September 1949 (42: 321-395).



mately flat, coarsely punctate; occipital carina often incomplete below; frons rarely with a median horn that is hollowed out above; hind corner of pronotum often incrassate and more or less strongly projecting; subtegular ridge heavy and variously specialized; tegula convex, flat, or concave above; areolet present, oblique; second recurrent vein with the lower half straight and the upper half curved or somewhat sinuate or angled, though never strongly angled as in *Tryphon*, with two bullae that are well separated to nearly confluent; nervellus broken between its lower 0.25 and its upper 0.25; tarsal claws pectinate only basally to pectinate nearly to the apex; second tergite smooth or with a more or less distinct transverse postmedian groove, impunctate to strongly punctate; ovipositor sheath linear, a little broader basally, flexible in its basal 0.4 (fig. 22); ovipositor straight or weakly sinuate, tapered to a sharp point, usually about 1.3 as long as the apical depth of the abdomen (fig. 22).

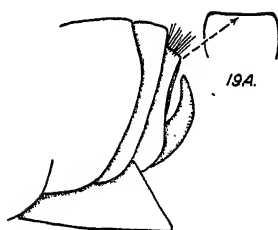
*Monoblastus* is related to *Thibetoides*, *Chiloplatys*, *Dyspetus*, *Scolomus*, *Cosmoconus*, and *Tryphon*, and seems to be near their prototype. *Thibetoides* and *Chiloplatys* are only little removed from *Monoblastus*.

Hartig proposed *Monoblastus* for the species of *Tryphon* carrying a single stalked egg on the ovipositor and having apparently simple claws; and *Polyblastus* for those carrying many eggs on the ovipositor and having pectinate claws. Until rather recently the name *Monoblastus* has been erroneously applied to *Rhorus*, a genus of Mesoleiinae having simple eggs and pectinate claws. In *Monoblastus*, Hartig included several described species and a new species called *Monoblastus caudatus*. Viereck (1914, Bull. U. S. Nat. Mus. 83:97) stated that *caudatus* was the genotype because the genus was monobasic. Though his datum was incorrect, there seems no reason to discard his choice. Hartig's "description" of *Monoblastus caudatus* consists only of a figure (plate 4, fig. 3) of the female abdomen in side view, with a stalked egg on the ovipositor. The figure, the most significant character of which is the length of the ovipositor, fits perfectly *Phaestus sericeus* Brischke 1892, and perhaps as well *Tryphon compuncator* Gravenhorst 1829. It certainly is of a species of the genus *Monoblastus* as interpreted here, but present information does not prove its exact identity.

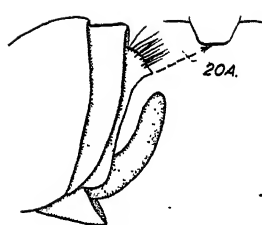
The genus *Monoblastus* contains a diverse set of species, differing from one another in so many obvious structural characters as to suggest segregation into subgenera or additional genera. There is, however, a confusing lack of correlation and an intergradation in the characters. The species known to us may be divided into four species groups as

#### EXPLANATION OF PLATE III

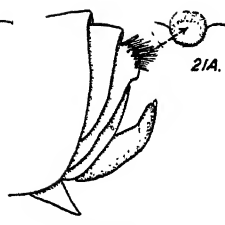
FIG. 19. *Erromenus planus* ♀, end of abdomen. FIG. 19a. *Erromenus planus* ♀, seventh tergite from behind. FIG. 20. *Erromenus caelator* ♀, end of abdomen. FIG. 20a. *Erromenus caelator* ♀, seventh tergite from behind. FIG. 21. *Erromenus nasalis* ♀, end of abdomen. FIG. 21a. *Erromenus nasalis* ♀, seventh tergite from behind. FIG. 22. *Monoblastus feria* ♀, end of abdomen. FIG. 23. *Monoblastus innumerabilis*, subtegular ridge. FIG. 24. *Monoblastus montezuma* subtegular ridge. FIG. 25. *Monoblastus macer*, subtegular ridge. FIG. 26. *Monoblastus dionnei*, subtegular ridge. FIG. 27. *Monoblastus kaniacensis*, subtegular ridge. FIG. 28. *Monoblastus feria rossi*, subtegular ridge. FIG. 29. *Monoblastus feria feria*, subtegular ridge. FIG. 30. *Monoblastus davisi*, subtegular ridge. FIG. 31. *Monoblastus philanthoides*, subtegular ridge.



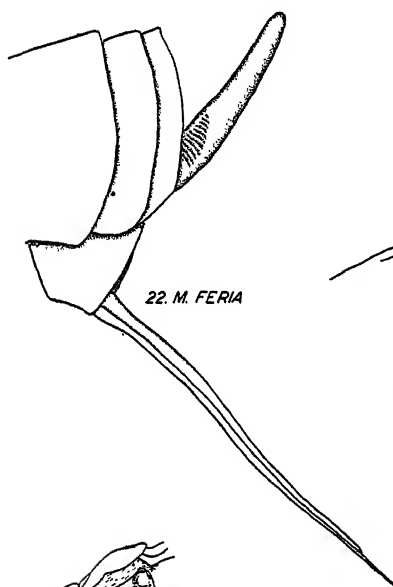
19. *E. PLANUS*



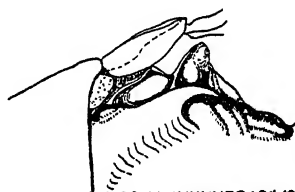
20. *E. CAELATOR*



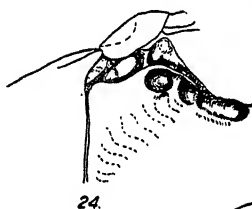
21. *E. NASALIS*



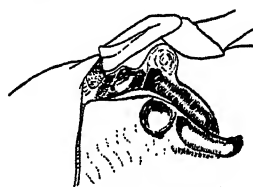
22. *M. FERIA*



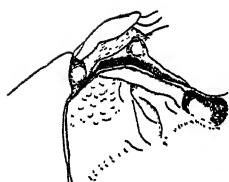
23. *M. INNUMERABILIS*



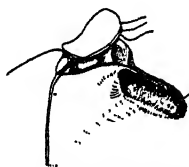
24.



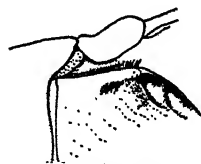
25. *M. MACER*



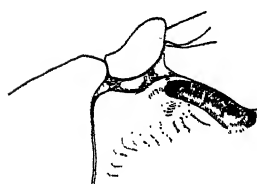
26. *M. DIONNEI*



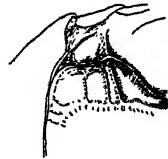
27. *M. KANIACENSIS*



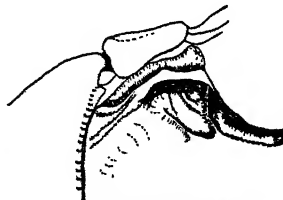
28. *M. FERIA ROSSI*



29. *M. FERIA FERIA*



30. *M. DAVISI*



*M. PHILANTHOIDES*

treated below. The Palaearctic species mentioned have not before been referred to the genus *Monoblastus*.

*Macer group*. Second tergite with very fine weak punctures, apparently impunctate; nervellus broken above the middle (sometimes at or below the middle in *M. dionnei*); epipleurum of third tergite about 4.0 as long as wide; epipleurum of fourth tergite about 1.7 as long as wide and separated from its tergite by a crease only basally; hind corner of pronotum heavy and projecting; notaulus absent or represented by a weak broad groove; basal and apical halves of clypeus usually not completely separated by a transverse ridge. The Nearctic *proximus*, *innumerabilis*, *montezuma*, *macer*, and *dionnei* and the Palaearctic *Ichneumon brachyacanthus* Gmelin 1790 are included. The species *dionnei* is somewhat atypical.

*Davisi group*. Second tergite with rather coarse punctures; nervellus broken below its middle; epipleurum of third tergite about 2.5 as long as wide; epipleurum of fourth tergite about 1.5 as long as wide, completely separated by a crease; hind corner of pronotum very heavy and projecting; notaulus very strong. Only the Nearctic *davisi* is included.

*Feria group*. Second tergite with distinct, rather close punctures; nervellus broken at or below its middle; epipleurum of the third and fourth tergites about 4.0 or 5.0 as long as wide (narrower in *proditor*), both completely separated by a crease; hind corner of pronotum normal, not heavy nor strongly projecting; notaulus absent or represented by a weak broad groove. A diverse set of species is included: the Nearctic *kaniacensis*, *favonius*, *eurus*, *feria*, and *atroferia* and the Palaearctic *Tryphon compunctor* Gravenhorst 1829, *Phaestus sericeus* Brischke 1892, and the aberrant *Tryphon proditor* Gravenhorst 1829. Of these, *favonius* and *eurus* and *feria* and *atroferia* form two closely knit subgroups.

*Philanthoides group*. Second tergite coarsely to very finely punctate; nervellus broken below the middle; epipleura of third and fourth tergites vestigial; hind corner of pronotum normal, not heavy nor strongly projecting; notaulus absent or represented by a weak broad groove; clypeus usually evenly convex and evenly punctate, without a difference in color between its basal and apical halves. The Nearctic *philanthoides*, the Neotropical *phaeopteris* and *melanopteris*, and the Palaearctic *Tryphon luteomarginatus* Gravenhorst 1829 are included. Of these the two Neotropical species are very closely related to each other, the others more distantly.

#### KEY TO THE AMERICAN SPECIES OF MONOBLASTUS

1. First five tergites with a broad apical yellow margin, the rest of the abdomen black; face and pronotum black marked with yellow; hind femur black with the apex yellow; face and body very coarsely punctate (*philanthoides* group, in part)..... 12. *philanthoides*  
First five tergites not marked with yellow; face, pronotum, and hind femur not black marked with yellow; face and body less coarsely punctate..... 2
2. Wings brown or black; face finely and rather sparsely punctate, medially with the punctures separated by about 4 times their diameter; vertex with a prominent swelling just behind the ocelli; lateral propodeal carina obsolete or very blunt at the level of the spiracle (Neotropical species, part of the *philanthoides* group)..... 3
- Wings hyaline or subhyaline; face rather coarsely and densely punctate, medially with the punctures separated by less than their diameter and somewhat confluent; vertex without a prominent swelling; lateral pro-

- podeal carina not obsolete or blunt at the level of the spiracle (Nearctic species)..... 4
3. Head, thorax, abdomen, and legs fulvous, usually marked with dark brown; wings brown; first tergite about as wide at its basal corners as at its spiracles; occipital carina incomplete below.....13. *phaeopteris*
- Head, thorax, and legs black, the abdomen red; wings black; first tergite conspicuously wider at its basal corners than at its spiracles; occipital carina joining the hypostomal carina about 0.8 the basal width of the mandible from its lower end.....14. *melanopteris*
4. Second tergite with very fine indistinct punctures or apparently impunctate; epipleurum of fourth tergite much wider than that of the third, not or incompletely separated from its tergite by a crease; nervellus broken above its middle except sometimes in *M. dionnei* (macer group)..... 5
- Second tergite with distinct punctures; epipleurum of fourth tergite not conspicuously wider than that of the third, frequently very narrow, always separated from its tergite by a complete crease or carina; nervellus broken at or below its middle..... 9
5. Subtegular ridge projecting upwards as a thin sharp-edged lamina (fig. 26); tegula flat above; basal and apical halves of clypeus separated by a rather strong angle.....5. *dionnei*
- Subtegular ridge not forming an upwards-projecting lamina whose entire upper edge is thin and sharp (figs. 23 to 25); tegula above either convex, concave, or irregularly shaped; basal and apical halves of clypeus not separated by a definite angle..... 6
6. Tegula strongly concave above, its upper outer margin sharp and elevated; ventral end of combined occipital and hypostomal carinae very high and projecting ventrally as a blunt tooth; antenna and first tergite exceptionally long and slender.....4. *macer*
- Tegula not strongly concave above, its upper outer margin rounded, or angled and weakly elevated; ventral end of combined occipital and hypostomal carinae not unusually high nor projecting; antenna and first tergite shorter..... 7
7. Occipital carina reaching hypostomal carina at about 0.5 the basal width of the mandible from its lower end.....2. *proximus*
- Occipital carina either not reaching the hypostomal carina (incomplete below) or reaching the hypostomal carina at about 1.0 the basal width of the mandible from its lower end..... 8
8. Occipital carina usually incomplete below, when reaching the hypostomal carina joining it at an angle of about 40°; fore wing about 5 mm. long.....3. *montezuma*
- Occipital carina usually complete below, joining the hypostomal carina at an angle of about 80°; fore wing about 7 mm. long.....1. *innumerabilis*
9. Notalus very strong; tarsal claws conspicuously pectinate (*davisi* group),.....11. *davisi*
- Notalus absent or very weak; tarsal claws apparently simple, pectinate only at the base (*feria* group).....10
10. Nervellus broken near its middle; occipital carina usually not reaching the hypostomal carina (incomplete below).....6. *kaniacensis*
- Nervellus broken below its middle; occipital carina reaching the hypostomal carina.....11
11. Costula present; posterior 0.4 of subtegular ridge containing a deep longitudinal slot bordered above and below by a sharp margin; penis without spine-like setae.....12
- Costula absent; posterior 0.4 of subtegular ridge not containing a longitudinal slot, although bordered below by a deep groove; penis with four subapical spine-like setae.....14
12. Second and third tergites black, with only their apical margins more or less ferruginous; hind coxa ferruginous.....10. *atroferia*
- Second and third tergites ferruginous or partly ferruginous; hind coxa ferruginous or blackish.....13
13. Hind coxa mostly or entirely blackish.....9a. *feria rossi*
- Hind coxa entirely ferruginous.....9b. *feria feria*
14. Apical propodeal carina not stronger than the lateral longitudinal carina, angled at its junctures with the non-interstitial basal and apical sections of the lateral carina; second and third tergites entirely ferruginous or each

black with its apical part ferruginous; apex of hind tibia not conspicuously darker than the rest. . . . . 7. *favonius*  
 Apical propodeal carina stronger than the lateral longitudinal carina, its direction unchanged at its juncture with the approximately interstitial basal and apical sections of the lateral carina; second and third tergites black with the apical margin narrowly pale; apex of hind tibia conspicuously darker than the rest. . . . . 8. *eurus*

# 1. *Monoblastus innumerabilis* Davis, new combination

Figure 23

*Otlophorus innumerabilis* Davis, 1897. Trans. Amer. Ent. Soc. 24: 276. Type: ♀, Washington Territory (Philadelphia).

*Nervellus broken distinctly above the middle; clypeus medially without a distinct median transverse ridge; occipital carina strongly incurved below to join the hypostomal carina at an angle of 80° at 1.1 the basal width of the mandible from its lower end, the occipital carina sometimes incomplete near its place of juncture with the hypostomal carina.*

Fore wing about 7.2 mm. long; clypeus about 2.5 as wide as long, its apical impunctate section about as long as its basal punctate section, the two sections meeting across the middle of the clypeus in a weak rounded angle which in the median 0.25 of the clypeus is obsolete; face rather coarsely and very closely punctate, some of the punctures somewhat confluent; occipital carina joining the hypostomal carina at an angle of about 80° at about 1.1 the basal width of the mandible from its lower end, the occipital carina frequently weak or incomplete near its juncture with the hypostomal carina; hind corner of pronotum an elevated, pointed, tooth-like lobe; lateral section of prepectal carina bowed forward at the sternaulus, ending near the lower 0.33 of pronotum, its upper end curved forward; subtegular ridge a longitudinal ridge with its upper side about vertical, ending posteriorly in a high oblique carina, the anterior end of which is subtended by an irregular pit or short groove (fig. 23); tegula above flat posteriorly, concave anteriorly, antero-laterally with a rather sharp raised upper margin; nervellus broken near its upper 0.35; tarsal claws with several long basal pecten teeth; propodeum weakly rugulose, its costula usually lacking; first tergite of male about 1.7 as long as wide, of female about 1.6 as long as wide; second tergite without a transverse postmedian groove; its punctures very weak and fine so that it appears impunctate; epipleurum of third tergite about 4 times as long as wide, completely separated by a crease; epipleurum of fourth tergite about 1.7 as long as wide, separated from its tergite by a crease only basally; spiracle of third tergite separated from the edge of the tergite by its diameter in the male, by 2.5 its diameter in the female.

Black. Mandible, palpi, legs beyond coxae, and abdomen except basal 0.65= of first segment ferruginous; tegula and apical part of clypeus dark ferruginous; antenna tinged with ferruginous, especially below; wings tinged with reddish brown; extreme apices of coxae more or less ferruginous; base of maxillary palpus and apical part of hind tibia and of hind tarsus infusate.

Davis originally included a considerable number of species in his *Otlophorus innumerabilis*. Cresson (1928, Mem. Amer. Ent. Soc. 5: 19) designated a female from Washington State as lectotype, but in the arranging of the types at the Academy of Natural Sciences of Philadelphia a female from Colorado was labeled the lectotype. The only

female from Washington known to have been in Davis' series, and therefore the only specimen conforming with Cresson's lectotype designation, is a member of the present species, but the erroneously labeled specimen belongs to *Monoblastus montezuma* as defined in this revision. The false lectotype was the basis for the synonymy of *affinis* (= *montezuma*) with *innumerabilis* in 1944 (Townes, Mem. Amer. Ent. Soc. 11:155) and for numerous determinations of *montezuma* as *innumerabilis* made by the authors up until the year 1946, when the error was discovered.

*Specimens:* ♂, ♀, G. Alpine Cr., Tahoe, Calif., July 7, 1915, E. P. VanDuzee (Washington and Townes). ♂, Carrville, Trinity Co., Calif., 2400-2500 ft., May 16, 1934, T. G. H. Aitken (Townes). ♂, Carrville, Trinity Co., Calif., 2400-2500 ft., May 27, 1934 (Bohart). ♂, ♀, Dardanelle, Calif., July 2 and 8, 1948, H., M., G., D., & J. Townes (Townes)<sup>2</sup>. ♂, Ft. Seward, Calif., June 7, 1935, E. W. Baker (Washington). ♂, Los Angeles Co., Calif., D. W. Coquillett (Washington). ♂, Mariposa Co., Calif., July 2, 1933 (Bohart). ♀, Yorkville, Mendocino Co., Calif., April 24, 1928, E. P. VanDuzee (San Francisco). ♂, ♀, Nevada (Philadelphia and Townes). ♂, Summer Lake, Oreg., June 16, 1938, Gray and Schuh (Corvallis).

## 2. *Monoblastus proximus*, new species

*Nervellus broken above the middle; clypeus without a distinct median transverse ridge; occipital carina joining the hypostomal carina at an angle of 45° at 0.5 the basal width of the mandible from its lower end.*

Fore wing about 7.0 mm. long; clypeus about 2.5 as wide as long, its apical impunctate section 1.0 to 1.4 as long as its basal punctate section, the two sections meeting without forming any angle; occipital carina joining the hypostomal carina at an angle of about 45° at about 0.5 the basal width of the mandible from its lower end; lateral section of prepectal carina bowed forward at the sternaulus, ending near the lower 0.25 of the pronotum, its upper end not curved forward; sub-regular ridge a rounded longitudinal ridge, its upper side sloping steeply and with a few strong vertical rugae or ridges, posteriorly ending in a high oblique rounded carina; tegula posteriorly somewhat convex, anteriorly slightly concave, its antero-lateral upper margin not sharp nor distinctly raised; nervellus broken near its upper 0.38; propodeum weakly rugulose and more or less punctate, its costula usually present; first tergite of male about 2.0 as long as wide, of the female about 1.6 as long as wide. Agrees otherwise with the structural description of *M. innumerabilis*.

Black. Mandible, palpi, tegula, legs beyond coxae, and abdomen except basal part of first tergite ferruginous; clypeus dark ferruginous; antenna tinged with ferruginous, more strongly below and apically; wings tinged with reddish brown; coxae entirely ferruginous to entirely black; apical part of hind tibia and of hind tarsus somewhat infuscate.

<sup>2</sup>In 1948 we collected a considerable amount of ichneumonid material in Colorado and California, with the aid of a grant from the American Philosophical Society. In the Tryphonini, the material includes some new records and about ten additional new species of *Polyblastus* (*Labrocionus*), *Ctenochra*, and *Erromenus*. It was not possible to add the new species and records to the first part of this revision, but the addition has been made to this the second part.

*Type*: ♀, Berkeley, Calif., Apr. 30, 1939, C. D. Michener (Townes).

*Paratypes*: ♂, collected with the type (Townes). 2 ♀, Antioch, Calif., Apr. 21, 1934 (San Francisco). ♀, Antioch, Calif., Apr. 25, 1936 (Corvallis). ♀, Camino, Calif., June 30, 1948, H., M., G., & D. Townes (Townes). 3 ♀, Davis, Calif., Apr. 6, 1936, R. M. Bohart (San Francisco). ♀, Fairfax, Marin Co., Calif., June 4, 1911, E. C. VanDyke (San Francisco). ♀, Hastings Natural History Reserve, Santa Lucia Mts., Jamesburg, Calif., June 7, 1938, C. D. Michener (Townes). ♀, Ft. Seward, Calif., May 31, 1935, E. W. Baker (Townes). ♂, Southern California (Philadelphia). ♂, ♀, Craigs Mt., Ida., (Philadelphia). ♂, Moscow, Ida. (Townes). ♀, Ochoco Pass, 4800 ft., Oreg., July 13, 1936, H. A. Scullen (Corvallis). ♀, Pullman, Wash., June 17, 1932, H. A. Scullen (Washington).

### 3. *Monoblastus montezuma* Cameron, new combination

Figure 24

*Tryphon montezuma* Cameron, 1886. Biol. Centr.-Amer., Hymen. 1: 286. Type, ♂, Ciudad de Durango, Mexico, 8,100 ft. (London).

*Oolophorus affinis* Ashmead, 1901. Psyche 9: 148. New synonymy. Type: ♂, Las Vegas Range between Pecos and Sapello rivers, N. Mex., 11,000 ft. (Washington).

*Tryphon innumerabilis* Townes, 1944. Mem. Amer. Ent. Soc. 11: 155. Synonymy (in part).

*Nervellus* broken distinctly above the middle; clypeus without a distinct median transverse ridge; occipital carina usually incomplete below, when complete joining the hypostomal at an angle of  $40^\circ$  at 1.0 the basal width of the mandible from its lower end; head apparently deeper than in other species.

Fore wing about 5.0 mm. long; clypeus about 2.3 as wide as long, its apical impunctate section about 0.7 as long as its basal punctate section, the two sections meeting without forming any angle; occipital carina usually incomplete below, when complete joining the hypostomal carina at an angle of about  $40^\circ$  at about 1.0 the basal width of the mandible from its lower end; malar space longer than usual; head apparently deeper than in other species of the genus; lateral section of prepectal carina bowed weakly forward at the sternauleus, ending near the lower 0.2 of pronotum, its upper end not curved forward; subtegular ridge a rather sharp longitudinal ridge, its upper side vertical, ending posteriorly in a high oblique carina, and in the posterior part of its lateral face a deep rounded pit (fig. 24); tegula posteriorly somewhat convex, anteriorly slightly concave, its antero-lateral upper margin not sharp nor distinctly raised; nervellus broken near its upper 0.33; propodeum more or less distinctly rugulose and punctate, its costula present; first tergite of male about 2.0 as long as wide, of the female about 1.6 as long as wide. Agrees otherwise with the structural description of *M. innumerabilis*.

Black. Mandible, palpi, tegula, legs beyond coxae, and abdomen beyond first tergite ferruginous; apical part of clypeus dark ferruginous; antenna tinged with ferruginous, more strongly tinged beneath and apically; wings slightly darkened; coxae sometimes more or less ferruginous apically; apical part of first tergite ferruginous; hind tibia and tarsus somewhat infuscate towards their apices; hind femur often infuscate in specimens from high altitudes in the Rocky Mts., rarely infuscate in others.

*Specimens:* Many males and females from ALBERTA (Banff, Bilby, Cypress Hills, Radnor, and Waterton); ARIZONA (near Alpine); BRITISH COLUMBIA (Saratoga Beach of the Oyster River on Vancouver Island); CALIFORNIA (Camino, Humboldt Co., San Mateo Co., Tallac Lake at Tahoe, Upper Echo Lake at 7400 ft., and Yosemite Park at 7000 ft.); COLORADO (near Estes Park, Florissant, Rocky Mt. National Park at 9400 ft., and Steamboat Spring); ILLINOIS (Carlinville); MANITOBA (Awene); MICHIGAN (Douglas Lake); MINNESOTA (Cook Co., Eagle Bend, and Traverse Co.); NEVADA; NEW HAMPSHIRE (Pinkham Notch); NEW JERSEY (Alpine and Ramsey); NEW MEXICO (Beulah at 8000 ft.); NEW YORK (southern Adirondack Mts., Bemus Point, Ithaca, Millwood, Rock City in Cattaraugus Co., Rome, Saranac Lake, and Syracuse); NORTH CAROLINA (Pisgah Mt. at 4800 to 5300 ft.); NORTH DAKOTA (Tower City); OHIO (Brown Co.); ONTARIO (Ottawa and Waubamie); OREGON (Cherry Creek on the west side of Klamath Lake at 4175 ft., Forest Grove, Lick Creek in Wallowa National Forest at 4600 ft., Queen Mine above Cornucopia at 5000 ft., and Triangle Lake); QUEBEC (Brome, Burbridge, Danford Lake, Gracefield, Joliette, Lac Ste. Marie, Laurentian Mts., Sweetsburg, and Wright); SASKATCHEWAN (Snowden); SOUTH DAKOTA (Brookings); TEXAS; WASHINGTON (Elbe, Mt. Rainier at 2900 ft., and Snoqualmie Pass); and WYOMING (Big Horn Mts. near Buffalo, at 6000 ft.).

This species appears to occur in the Transitional Zone and the warmer part of the Canadian Zone throughout Canada, the United States, and probably also of Mexico. There is one generation a year, most of the adults being on the wing in June and early July. Early and late records of interest are: May 20 at Forest Grove, Oreg.; May 24 at Triangle Lake, Oreg.; May 24 near Alpine, Ariz. (8200 ft.); May 27 at Burbridge, Que.; May 30 at Syracuse, N. Y.; May 31 at Brome, Que.; July 12 at Aweme, Man.; July 17 at Tahoe, Calif.; July 20 at Bilby, Alta.; July 21 at Ottawa, Ont.; July 25 at Elbe, Wash.; August 12 in Wallowa National Forest, Oreg., at 4600 ft.; August 21 in Cook Co., Minn.; and September 2 at Upper Echo Lake, Calif., at 7400 ft.

#### 4. *Monoblastus macer*, new species

Figure 25

*Nervellus broken distinctly above the middle; tegula strongly concave above.*

Fore wing about 6.0 mm. long; clypeus about 2.8 as wide as long, its apical impunctate section about 0.7 as long as its basal punctate section, the two sections meeting in a rounded obtuse angle which is obsolescent in the central 0.3 of its length; clypeus with a false inner glabrous apex projecting slightly beyond its true setiferous apex; punctures of face rather coarse and so close as to be irregular in shape; antenna exceptionally long; occipital and hypostomal carinae strongly elevated below and produced into a blunt scoop-shaped tooth projecting ventrally below the mandible, the two carinae joining near the apex of the process; hind corner of pronotum produced into an elevated, triangular, tooth-like process; lateral section of prepectal carina bowed weakly forward at the sternaulus, ending near lower 0.2 of pronotum, its upper end often turned forward; subtegular ridge projecting upwards as a low lamina with a bowed margin, its highest point meeting a dorsal short strong ridge, its lateral face posteriorly with a pit (fig. 25); tegula strongly



concave above, with a convex area mesally behind its middle, anteriorly and laterally its upper margin sharp and strongly elevated; nervellus broken near its upper 0.4; basal half of tarsal claws coarsely pectinate; propodeum weakly and indistinctly punctate, its costula lacking; first tergite about 2.65 as long as wide in the male, about 2.45 as long as wide in the female; second tergite without a postmedian transverse groove, its punctures very weak and fine so that it appears impunctate; epipleurum of third tergite about 4 times as long as wide, completely separated by a crease; epipleurum of fourth tergite about 1.7 as long as wide, separated from its tergite by a crease only basally; spiracle of third tergite separated from the lower edge by its diameter in the male, by 2.5 its diameter in the female.

Black. Mandible, palpi, tegula, legs, and abdomen beyond the first tergite ferruginous, the palpi, trochanters, and fore and middle tibiae and tarsi very pale; apical part of clypeus dark ferruginous; scape and pedicel pale ferruginous, infusate above; flagellum pale below, its apical part fulvous; hind coxa often blackish basally; hind femur usually infusate at its apex above; hind tibia pale, infusate apically and sub-basally, to entirely infusate; hind tarsus more or less infusate; apical part of first tergite ferruginous. Sometimes the second and following tergites, especially the apical ones, are vaguely marked with fuscous.

*Type:* ♀, in rich moist bottomland woods on Northwest Branch at University Lane, Takoma Park, Md., July 1, 1943, H. Townes (Townes).

*Paratypes:* 2 ♂, 8 ♀, taken with the type (Townes). ♂, ♀, Bowie, Md., June 7, 1945, H. Townes (Washington). 2 ♂, 3 ♀, Bowie, Md., June 24, 1945, H. & M. Townes (Townes). ♂, Cabin John, Md., 1916, R. M. Fouts (Washington). 24 ♂, 14 ♀, taken at Takoma Park, Md., by H. & M. Townes as follows: ♂, May 30, 1944; ♂, June 2, 1944; 7 ♂, June 14, 1942; 10 ♂, 4 ♀, June 20, 1943; 3 ♂, 3 ♀, June 21, 1942; ♂, June 28, 1943; and ♂, 7 ♀, July 5, 1942 (all in Townes collection); ♀, Takoma Park, Md., July 6, 1944, H. Townes (Washington). ♀, Moorestown, N. J., June 18, 1939, H. & M. Townes (Townes). 2 ♂, Moorestown, N. J., June 23, 1939, H. & M. Townes (Townes). ♂, Moorestown, N. J., July 2, 1939, H. & M. Townes (Townes). ♂, Riverside, N. J., June 18, 1939, H. Townes (Townes). ♂, Bernus Point, N. Y., July 2, 1937, H. Townes (Townes). ♂, 3 ♀, Farmingdale, N. Y., July 2, 1938, H. & M. Townes (Townes). ♀, Farmingdale, N. Y., July 3, 1938, H. & M. Townes (Townes). ♂, Cleveland, Ohio, F. D. DeGant (Washington). 9 ♂, 6 ♀, taken at Philadelphia, Pa., by H. & M. Townes as follows: 5 ♂, June 16, 1941; 2 ♂, June 24, 1941; 2 ♂, 2 ♀, June 29, 1941; and 4 ♀, July 9, 1941 (all in Townes collection). ♂, July 21, 1931 (Washington).

This species occurs in the Eastern United States from New York and Ohio south to Virginia. Its habitat is the rank herbage of moist bottomland woods, where it is on the wing from late May to early July.

##### 5. *Monoblastus dionnei* Provancher, new combination

Figure 26

*Tryphon Dionnei* Provancher, 1879. Nat. Canad. 11: 256; Faune p. 414. Type: ♀, Quebec (Quebec).

*Subtegular ridge projecting upward as a simple, thin, sharp-edged lamina; tegula flat above.*

Fore wing about 5.5 mm. long; clypeus about 2.3 as wide as long, its apical impunctate section about 0.8 as long as its basal punctate section, the two sections meeting in a rounded obtuse angle; punctures of face close and rather coarse, some of them somewhat confluent; occipital carina joining hypostomal carina at an angle of about  $70^\circ$  at about 0.8 the basal width of the mandible from its lower end; hind corner of pronotum an elevated, blunt, tooth-like lobe; lateral section of prepectal carina bowed forward at the sternaulus, ending near the lower 0.2 of the pronotum, its upper end usually curved forwards; subtegular ridge projecting upwards as a thin sharp-edged lamina with the upper margin bowed, its lateral face posteriorly with oblique rugae and grooves (fig. 26); tegula flat above, its anterior half bordered with a slightly raised margin; nervellus broken near its upper 0.45, usually distinctly above but sometimes below the middle; tarsal claws pectinate on their basal halves; propodeum rugulose, its costula present though often weak; first tergite of male about 1.7 as long as wide, of female about 1.6 as long as wide; second tergite without a postmedian transverse groove, its punctures very fine and weak so that it appears impunctate, sometimes more or less finely longitudinally rugulose; epipleurum of third tergite about 4 times as long as wide, completely separated from its tergite by a crease; epipleurum of fourth tergite about 2.0 as long as wide, separated by a crease basally but not apically; spiracle of third tergite almost adjacent to its lower margin in the male, separated by about its diameter in the female.

Black. Apical part of clypeus, mandible, palpi, scape, pedicel, tegula, legs, abdomen beyond the first tergite, and apical part of first tergite ferruginous; flagellum pale below, fulvous apically; wings hyaline; apex of hind femur and basal 0.15 and apical 0.3 of hind tibia infusate; second and third tergites of male sometimes marked with fuscous.

*Specimens:* Many males and females from MAINE (Bar Harbor, Capens, Oquossoc, and Paris); MASSACHUSETTS (Cohasset, Lexington, Nantucket, North Adams, and Truro); MICHIGAN (East Lansing, Iosco Co., Isabella Co., and Osceola Co.); MINNESOTA (Houston Co., Itasca Park, and John Latch State Park in Winona Co.); NEW BRUNSWICK (Frederickton, St. John, and Waweig); NEW HAMPSHIRE (Glen House, Gorham, Mt. Madison, Mt. Washington at 2000 ft., Nelson, Pinkham Notch, and Randolph); NEW YORK (Ithaca, Labrador Lake in Cortland Co., Mix Creek Valley in Cattaraugus Co., Mt. Marcy, Oneonta, Otsego Lake, Ringwood, Rome, Syracuse, Utica, Waterville, and Woodville); NOVA SCOTIA (Baddeck and Truro); ONTARIO (Normandale and Ottawa); PENNSYLVANIA (Roxborough, Spring Brook, and Wilawana); QUEBEC (Aylmer, Brome, Cascapedia River, Cottage Beaulieu, Covey Hill, Gatineau Point, Georgeville, Gracefield, Grand Grève on the Gaspé, Hemmingford, Hull, Joliette, Knowlton, Meach Lake, Megantic, Montreal, Quebec, Rigaud, Stoneham, and Valley Junction); and VERMONT (Burlington and St. Albans).

This species occurs in the Canadian and the northern part of the Transitional zones from the Gaspé Peninsula south to Pennsylvania and west to Minnesota. Its habitat is more or less shaded grassy places around the edges of woods, along woodland roads and trails, and among and under trees and bushes in more open places. There is a single

generation a year, the adults beginning to emerge in late May and continuing on the wing until the middle of July. Males precede the females by a very few days and are scarcer than females toward the last of the adult season. Early and late collecting records of interest are May 25 at Ithaca, N. Y., and at Roxborough, Pa.; May 27 in Houston Co., Minn.; May 28 at Syracuse, N. Y.; July 12 on the Cascapedia River, Que.; July 15 at Nelson, N. H., and at Grand Grève in the Gaspé Peninsula; July 16 at Ottawa, Ont.; and July 18 at Gorham, N. H. We have also a record of a female collected September 4 at Truro, Mass., by A. P. Morse.

#### 6. *Monoblastus kaniacensis* Hall, new combination

Figure 27

*Polyblastus kaniacensis* Hall, 1919. Psyche 26: 156. Type: ♀, "Kaniac" (=Kamiac) Butte, Wash. (Cambridge).

*Nervellus broken near its middle; occipital carina usually incomplete below.*

Fore wing about 5.4 mm. long; clypeus about 2.5 as wide as long, its apical impunctate section 1.2 to 1.7 as long as the basal punctate section, the two sections meeting in a rounded obtuse angle; face with rather coarse close punctures; occipital carina nearly always (especially in the male) obsolete below and ending far from the hypostomal carina, when reaching the hypostomal carina joining it at an angle of about 60° at about 0.8 the basal width of the mandible from its lower end; hind corner of pronotum rounded off, slightly elevated; lateral section of prepectal carina bowed forward at the sternaulus, ending near the lower 0.2 of the pronotum, its upper end usually somewhat curved forward; subtegular ridge a high round-edged longitudinal ridge, its upper side vertical, ending posteriorly in a high oblique carina below the anterior end of which is a pit, the pit often open below (fig. 27); tegula almost evenly convex; nervellus broken at or very near its middle; tarsal claws pectinate on their basal 0.66; propodeum with rather close, moderate sized punctures, its costula absent; first tergite of male about 1.5 as long as wide, of female about 1.4 as long as wide; second tergite frequently with a very weak postmedian transverse groove, its punctures sharp and of medium size; epipleura of third and fourth tergites about 4.5 as long as wide, completely separated from their tergites by a crease; in the male, spiracles of third and fourth tergites separated from the lower margin by about their diameter; in the female, spiracle of third tergite separated from the lower margin by about 4 times its diameter, of fourth tergite separated by about 6 times its diameter.

Black. Apical part of clypeus dark ferruginous; mandible black basally and ferruginous apically, the rest of it stramineous; palpi ferruginous; antenna piceous; wings hyaline; tegula stramineous; first trochanters piceous; legs beyond first trochanters ferruginous, the tibiae stramineous externally and often the femora piceous basally below; hind tibia infusate apically, often rather completely infusate with an external pale stripe; hind tarsus more or less infusate; first tergite black, usually with as much as its apical 0.35 ferruginous; second and following tergites entirely ferruginous or in the male each often with a large basal median fuscous area, the apical tergites sometimes entirely fuscous.

*Specimens:* ♂, Acme, Alta., June 16, 1928, H. L. Seamans (Ottawa). 39 ♂, 5 ♀, taken at Workman Creek, Sierra Ancha, Ariz., by H. & M. Townes in 1947 (Townes) as follows: 4 ♂, May 1; 2 ♂, May 3, 9 ♂, May 6; and 24 ♂, 5 ♀, May 8. ♂, near Sonora Pass, Calif., at 8500 ft., July 8, 1948, H., M., G., D., & J. Townes (Townes). 6 ♂, 3 ♀, near Estes Park, Colo., June 14 and 15, 1948, H., M., G., D., & J. Townes (Townes). ♀, Howe's Gulch, 6 mi. west of Ft. Collins, Colo., May 6, 1896, C. F. Baker (Washington). ♀, Grizzly Creek, Larimer, Co., Colo., July 19, 1896, C. F. Baker (Washington). ♂, Lyons, Colo., June 14, 1948, H., M., G. & D. Townes (Townes). 2 ♂, Muddy Pass, Colo., June 17, 1948, H., M., G., D., & J. Townes (Townes). ♂, Colo. (Washington). ♂, Juliaetta, Ida. (Townes). ♀, Potlach, Ida., May 28, 1930, J. M. Aldrich (Townes). ♀, Dunrae, Man., June 12, 1931, R. H. Handford (Ottawa). ♂, Kittson Co., Minn., June 15, 1941, H. P. Nicholson (St. Paul). 5 ♂, 3 ♀, Montana (Philadelphia, Townes, and Ottawa). ♀, Mt. Hood, Oreg. (Philadelphia). ♂, Soda Springs, Benton Co., Oreg., June 21, 1943, G. R. Ferguson (Corvallis). 9 ♂, 5 ♀, Strawberry Daniel Pass, Utah, June 18 and 19, 1948, H., M., G., D., & J. Townes (Townes). ♂, Big Horn Mts. near Buffalo, Wyo., 6000 ft., June 28, 1940, H. & M. Townes (Townes).

This is a western species occurring as far east as Manitoba and Minnesota. The series from Workman Creek, Ariz., was all taken on and among *Symphoricarpos* bushes that were infested by larvae of a *Blennocampa* (?), and the species has been collected from *Symphoricarpos* at Strawberry Daniel Pass, Utah. This shrub appears to be its usual habitat.

## 7. *Monoblastus favonius*, new species

*Nervellus broken far below its middle; subtegular ridge not containing a deep longitudinal slot; second tergite strongly punctate, ferruginous or black with the apical part ferruginous.*

Fore wing about 5.4 mm. long; clypeus about 3.2 as wide as long, its apical impunctate section about 1.3 as long as the basal punctate section, the two sections meeting in a rounded obtuse angle; face with rather coarse, very close punctures, some of which are somewhat confluent; occipital carina meeting the hypostomal carina at an angle of about 60° at about 0.5 the basal width of the mandible from its lower end; hind corner of pronotum a short rounded or bluntly pointed lobe, somewhat elevated; lateral section of prepectal carina bowed forward at the sternaulus, ending near the lower 0.25 of the pronotum, its upper end usually somewhat curved; subtegular ridge a rather sharp longitudinal ridge, its lower side ascending, its upper side vertical, ending posteriorly in a high oblique carina; tegula almost evenly convex; nervellus broken near its lower 0.27; tarsal claws pectinate at the base; propodeum with rather sparse distinct punctures; costula absent; apical propodeal carina not stronger than the lateral longitudinal carina, angled at its junctures with the non-interstitial basal and apical sections of the lateral carina; first tergite of male about 1.4 as long as wide, of female about 1.35 as long as wide; second tergite often with a very weak postmedian transverse groove; second tergite with sharp moderately coarse punctures; epipleura of third and fourth tergites

about 5 times as long as wide, separated from their tergites by a crease; in the male the spiracles of the third and fourth tergites separated from the lower margin by somewhat less than their diameter; in the female the spiracle of the third tergite separated from the lower margin of the tergite by about 3 times its diameter, of the fourth tergite separated by about 4 times its diameter; penis with two long stout subapical setae on each side (*M. eurus* is the only other species of the genus possessing these).

Black. Palpi and tegula pale whitish ferruginous; apical part of clypeus, mandible, antenna except above, legs beyond coxae, and abdomen of the female beyond the first tergite ferruginous; first tergite of the female with the apical margin ferruginous; abdomen of male blackish with the apical 0.2, 0.3, and 0.4 of the second, third, and fourth tergites respectively ferruginous; coxae ferruginous with the basal third blackish, to entirely piceous; hind tibia and tarsal segments more or less infuscate, especially towards their apices.

*Type*: ♂, Oakland, Calif., April 8, 1937, E. S. Ross (Townes).

*Paratypes*: 2 ♂, Fairfax, Marin Co., Calif., March 20, 1927, C. L. Fox (San Francisco). ♀, Humboldt Co., Calif., May 15, 1911, F. W. Nunnenmacher (Washington). ♀, Mt. Diablo, Calif., April 21, 1925, E. P. VanDuzee (San Francisco). ♀, Pentz, Butte Co., Calif., April 5, 1928, H. H. Keifer (San Francisco). ♀, Piñon Flat, San Jacinto Mts., Calif., May 18, 1939, E. G. Linsley (San Francisco). ♀, Yosemite Calif., May 28, 1921, E. C. Van Dyke (Townes). ♀, Yosemite, Calif., May 27, 1891 (Washington). ♀, Yosemite, Calif., May 9, 1941, W. P. Cockerell (Townes).

#### 8. *Monoblastus eurus*, new species

*Nervellus broken far below its middle; subtegular ridge not containing a deep longitudinal slot; second tergite rather strongly punctate, black.*

*Type male*: Fore wing 4.3 mm. long; clypeus 2.5 as wide as long, its basal punctate and apical impunctate sections of equal length, meeting in a rounded obtuse angle; face with rather coarse, rather close punctures, some of which are more or less confluent; occipital carina meeting the hypostomal carina at an angle of 60° at 0.5 the basal width of the mandible from its lower end; hind corner of pronotum a short, rounded or bluntly pointed lobe, somewhat elevated; lateral section of prepectal carina bowed forward at the sternaulus, ending near the lower 0.25 of pronotum, its upper end curved slightly forward; anterior part of subtegular ridge a longitudinal ridge with its upper side vertical, the posterior part a lamina arching upward and inward; tegula weakly convex above, strongly convex laterally, the lateral edge slightly rolled under; nervellus broken at its lower 0.25; tarsal claws pectinate at the base; propodeum rather weakly rugulose and punctate; costula absent; apical propodeal carina stronger than the lateral longitudinal carinae, its direction unchanged at its juncture with the approximately interstitial basal and apical sections of the lateral carina; first tergite 1.25 as long as wide; second tergite with sharp, close, medium sized punctures; second tergite with a very weak postmedian transverse groove; epipleura of third and fourth tergites about 4.5 as long as wide, completely separated from their tergites by a crease; spiracle of third and fourth

tergites separated from the lower margin by about their diameter; penis with two long stout subapical setae on each side (these lacking in all others of the genus but *M. favonius*).

Black. Apical part of clypeus, mandible, legs beyond coxae, and narrow apical margin of second and following tergites ferruginous; (palpi and antennae lacking in the type); tegula and hind tibia and tarsus pale stramineous, the apical 0.3 of hind tibia and all but the basal parts of the tarsal segments infusate.

*Type*: ♂, Plummers Island, Md., May 20, 1903, W. V. Warner (Washington).

### 9. *Monoblastus feria* Davis, new combination

Figures 22, 28, and 29

*Posterior part of subtegular ridge containing a deep longitudinal slot; abdomen beyond the first tergite largely or entirely ferruginous.*

Fore wing about 5.0 mm. long; clypeus about 2.4 as long as wide, its impunctate apical and punctate basal sections about equal in length, the sections meeting in a rounded obtuse angle; face with rather coarse, very close punctures, some of the punctures more or less confluent; occipital carina meeting hypostomal carina at an angle of about 75° at about 1.0 the basal width of the mandible from its lower end; hind corner of pronotum a short, round-pointed lobe, somewhat elevated; lateral section of prepectal carina bowed strongly forward at the sternaulus, ending near the lower 0.25 of the pronotum, its upper end straight or slightly curved forward; subtegular ridge high, anteriorly with its upper side vertical, posteriorly containing a deep oblique slot subtended by a deep groove, in the middle of the upper side a deep pit extending forward and downward (figs. 28 and 29); tegula medially weakly convex, laterally strongly convex; nervellus broken near its lower 0.34; tarsal claws pectinate on the basal half; propodeum weakly indistinctly punctate, its costula present; first tergite of male about 1.55 as long as wide, of female about 1.4 as long as wide; second tergite with a very weak postmedian transverse groove; second tergite with moderately small, rather indistinct punctures; epipleurum of third tergite about 5 times as long as wide, of fourth tergite about 4 times as long as wide, both separated from their tergites by a crease; in the male the spiracles of third and fourth tergites separated from the margin by about their diameter; in the female the spiracle of the third tergite separated from the margin by about 1.5 its diameter, of the fourth tergite by about 2.5 its diameter.

Black. Apical part of clypeus, mandible, palpi, antenna, tegula, legs, and all or much of abdomen except basal 0.66± of first tergite ferruginous, the mandible, palpi, tegula, and tarsi paler ferruginous than the rest; antenna above and apical 0.12± of hind tibia infusate; segments of hind tarsus somewhat infusate except basally; hind corner of pronotum and upper margin of mesopleurum tinged with ferruginous; wings hyaline; hind coxa ferruginous to piceous.

*Monoblastus feria* is represented by the two subspecies described below.

*Specimens*: See under the two subspecies.

9a. *Monoblastus feria rossi*, new subspecies

Figure 28

Structurally similar to *M. feria feria* except that the slot in the subtegular ridge averages a very little shorter and shallower, and is often crossed by an oblique ridge (fig. 28). This oblique ridge is usually absent or indistinct in *M. feria feria*.

Hind coxa piceous or black, its apical part sometimes ferruginous; tergites of male sometimes mostly infuscate but with at least the apical part of the second to fourth tergites ferruginous. Colored otherwise as in *M. feria feria*.

Type: ♀, Oakland, Calif., May 3, 1937, E. S. Ross (Townes).

Paratypes: 2 ♂, ♀, collected with the type (Townes). ♂, Ground Hog Basin, Big Bend Country of the Selkirk Mts., B. C., July 24, 1905, J. C. Bradley (Ithaca). ♂, 4 ♀, Steelhead, B. C., May 31, June 2, and June 11, 1933, H. B. Leach (Ottawa). 5 ♂, 4 ♀, Camino, Calif., June 27 and 29, 1948, H. M., G., & D. Townes (Townes). ♂, Humboldt Co., Calif., May 15, 1911, F. W. Nunnenmacher (Washington). ♂, Custer Co., Colo., T. D. A. Cockerell (Washington). ♀, Ft. Collins, Colo., Aug., C. F. Baker (Washington). ♀, Forrester's, Colo., July 21, 1895, C. F. Baker (Washington). 2 ♂, Rocky Mt. National Park at 9,400 ft., Colo., H. M., G., D., & J. Townes (Townes). ♀, Aspen Lake, Oreg., June 26, 1924, C. L. Fox (San Francisco).

This subspecies occurs west of the continental divide, apparently in the Transitional Zone.

9b. *Monoblastus feria feria* Davis, new combination

Figure 29

*Otlophorus innumerabilis* var. *feria* Davis, 1897. Trans. Amer. Ent. Soc. 24: 276.

Type: ♀, N. Y. (Philadelphia).

*Epachtes* (!) *basilicus* Davis, 1898. Trans. Amer. Ent. Soc. 24: 283. Type: ♀, Colo. (Philadelphia).

Structurally similar to the subspecies *M. feria rossi* except that the subtegular ridge averages a little higher and with a correspondingly deeper slot (fig. 29). The slot is usually not crossed by the oblique ridge that is often present in *M. feria rossi*.

Hind coxa ferruginous; abdomen beyond basal 0.66± of first tergite ferruginous. Colored otherwise as in *M. feria rossi*.

Specimens: Many males and females from CONNECTICUT (Wallingford); FLORIDA (Jacksonville); ILLINOIS (Dubois); KANSAS (Lawrence); MANITOBA (Aweme); MARYLAND (Bowie and Takoma Park); MASSACHUSETTS (Dedham and South Hadley); MICHIGAN (Clare Co., Lapeer Co., Midland Co., and Ottawa Co.); MINNESOTA (Lincoln Co. and Norman Co.); NEW HAMPSHIRE (Mt. Madison and Pinkham Notch); NEW YORK (Bemus Point, Huntington, Ithaca, Labrador Lake in Cortland Co., Maplecrest in the Catskill Mts., McLean, Oliverea, Rock City in Cattaraugus Co., Saranac Lake, and Syracuse); NORTH CAROLINA (Pisgah Mt. at 4,800 to 5,300 ft.); OHIO (Akron, Bridgeport, Columbus, and Put-in-Bay); ONTARIO (Bobcaygeon, Leamington, Mer Bleue, Merivale, Parry Sound, and Waubamie); PENNSYLVANIA (Charter Oak, Kingsley, North East, Spring Brook, and Trout Run); QUEBEC (Aylmer, Brome, Knowlton, Mason, and Stoneham); and VERMONT (Mt. Equinox).

This subspecies occurs in the Transitional Zone east of the continental divide. The record for Jacksonville, Fla., is out of its normal range. It is based on a specimen in the Washington Museum labeled "Jacksonville, Fla." with the style of label used by Mrs. A. T. Slosson. The adult habitat is the shaded grass of the edges of woods, clearings and trails in woods, and under trees and bushes in more open areas. There is a single generation a year which is on the wing in middle and late spring, from about May 20 to June 20, with a few early comers and late stragglers. Males average a few days earlier than females in appearance and disappearance. Early and late capture dates of interest are: May 15 at South Hadley, Mass. and at Ithaca, N. Y.; May 18 at Akron, Ohio; June 21 at Stoneham, Que.; June 22 at Ithaca, N. Y.; June 23 in Norman Co., Minn.; June 24 at Mt. Madison, N. H.; June 26 at Bemus Point, N. Y.; and July 1 at Waubamoc, Ont.

#### 10. *Monoblastus atroferia*, new species

*Posterior part of subtegular ridge containing a deep longitudinal slot; abdomen beyond the first tergite black.*

Fore wing about 5.2 mm. long. Structurally similar to *M. feria* except that the subtegular ridge is slightly more elevated, with its pit or slot slightly deeper, narrower, and bordered below by a slightly longer lamina. Also, in *M. feria* the large impunctate area of the mesopleurum is usually separated below from the mesopleural suture by a narrow area containing a few punctures, while in *atroferia* these punctures are nearly or quite absent.

Tibiae and tarsi stramineous tinged with ferruginous, the apical 0.25 of hind tibia and apices of the hind tarsal segments fuscous; coxae ferruginous; tergites black or blackish, their apical margins tinged with ferruginous. Colored otherwise as in *M. feria*. The color of the abdomen is the only reliable differentiating character between the two species.

*Type:* ♀, Syracuse, N. Y., May 30, 1938, H. & M. Townes (Townes).

*Paratypes:* 26 ♂, 5 ♀, collected with the type (Townes). ♂, ♀, Midland Co., Mich., June 7, 1938, R. R. Dreisbach (Townes). ♀, Labrador Lake, Cortland Co., N. Y., July 5, 1935, P. P. Babiý (Townes). ♂, Syracuse, N. Y., May 22, 1938, H. & M. Townes (Townes). ♂, Syracuse, N. Y., June 3, 1938, H. & M. Townes (Townes). 2 ♂, Pisgah Mt. at 4,800 to 5,300 ft., N. C., June 21, 1940, H. & M. Townes (Townes). ♂, Spring Brook, Pa., June 11, 1945, H. Townes (Townes). ♀, Youngwood, Pa., May 29, 1941, H. Townes (Townes).

This species seems restricted to the Transitional Zone of the northeastern United States. Its ecology and seasonal distribution seem about the same as in *M. feria*.

#### 11. *Monoblastus davis* Townes, new combination

Figure 30

*Tryphon nigrum* Davis, 1898. Trans. Amer. Ent. Soc. 24: 281. Preoccupied by Gravenhorst 1829. Type: ♂, Gaylord, Mich. (Philadelphia).

*Tryphon davis* Townes, 1944. Mem. Amer. Ent. Soc. 11: 155. New name.

*Notaulus very strong.*

Fore wing about 4.9 mm. long; clypeus about 2.5 as wide as long, its apical impunctate section and basal punctate section of about equal



length, meeting in a rounded obtuse angle; face with rather coarse, very close punctures, some of which are more or less confluent; occipital carina meeting hypostomal carina at an angle of about  $70^\circ$  at about 0.4 the basal width of the mandible from its lower end; hind corner of pronotum forming a large, blunt, heavy tooth whose apex is as far laterad as the lateral margin of the tegula; epomia exceptionally strong; lateral section of prepectal carina straight, ending just above lower corner of pronotum; notaulus sharp and strong (absent or indicated by a weak groove in the other species of the genus); mesoscutum between the notauli distinctly raised; subtegular ridge a rounded carina-like ridge, its central part bowed downward, its posterior part subtended by a few vertical rugae (fig. 30); tegula almost flat above, the margins rounded off; nervellus broken near its lower 0.35; tarsal claws coarsely pectinate on the basal half in the male, for most of their length in the female; propodeum somewhat rugulose; costula present; petiolar area usually with a median vertical carina; first tergite of male about 1.35 as long as wide, of female about 1.25 as long as wide; second tergite with a distinct transverse postmedian groove; second tergite with sharp, medium sized punctures; epipleurum of third tergite about 2.5 as long as wide, of fourth tergite about 1.5 as long as wide, both completely separated from their tergites by a crease; in the male, the spiracles of third and fourth tergites separated from the margin by a little less than their diameter; in the female, spiracle of third tergite separated from the margin by about 1.5 its diameter, of the fourth tergite separated from the margin by about its diameter.

Black. Clypeus, mandible, palpi, tegula, and legs ferruginous; mandible blackish or brownish basally; scape and pedicel ferruginous, dusky above; flagellum more or less ferruginous basally, apically, and below; wings hyaline; apical 0.15 of hind femur and 0.13 of hind tibia infusate; hind tarsus more or less infusate; abdomen of male black, the incisures more or less tinged with ferruginous; abdomen of female ferruginous, the first tergite except apically largely or entirely blackish, and the second and third tergites frequently more or less infusate; ovipositor sheath infusate.

*Specimens:* ♂, White Heath, Ill., June 25, 1939, J. C. Dirks (Townes). ♀, Iowa, June 20, 1934, H. C. Knutson (Washington). ♂, Farmingdale, N. Y., July 2, 1938, H. & M. Townes (Washington). ♂, Farmingdale, N. Y., July 3, 1938, H. & M. Townes (Townes). ♀, Millwood, N. Y., June 20, 1936, H. Townes (Townes). ♀, Thunder Bay Beach, Ont., July 26, 1941, H. S. Parish (Townes).

This appears to be a Transitional Zone species of the eastern United States, on the wing in July and late June.

## 12. *Monoblastus philanthoides* Cresson, new combination

Figure 31

*Tryphon philanthoides* Cresson, 1868. Trans. Amer. Ent. Soc. 2: 110. Type: ♀, Ill. (Philadelphia).

*Abdomen black, banded with yellow.*

Fore wing about 7.2 mm. long; clypeus about 2.2 as wide as long, with very coarse scattered punctures which tend to be confluent and give a rugose appearance; face protuberant above, with very close,

coarse punctures; occipital carina meeting hypostomal carina at an angle of about  $70^\circ$  at about 0.7 the basal width of the mandible from its lower end; hind corner of pronotum a short rounded lobe; lateral section of prepectal carina not curved at the sternaulus, its upper end curved forward to the front margin of mesopleurum to meet it near the middle of the pronotum; subtegular ridge a high, up-bowed, lamella-like ridge, medially overhanging, subtended by some oblique rugae, and met posteriorly from below by a long oblique carina (fig. 31); tegula rather strongly convex, anteriorly with a mesal pit-like depression; nervellus broken near its lower 0.38; tarsal claws pectinate nearly to the apex; propodeum strongly rugose; costula present; first tergite about 1.0 as long as wide; second tergite with strong, rather coarse punctures and with a strong postmedian transverse groove; epipleura of third and fourth tergites apparently represented by very narrow membranous margins to the tergites; spiracle of third tergite separated from the margin of the tergite by about 3 times its diameter, of the fourth tergite separated by about 4 times its diameter.

**Black.** Apical 0.4 of mandible, sometimes the apical 0.3 of clypeus, pedicel and flagellum except above, and tegula dark ferruginous; antenna brown above; two spots on face (sometimes confluent), scape except above, a spot covering upper end of epomia, scutellum except for a basal semicircular area, postscutellum, apices of femora, fore and middle tibiae and tarsi, all but apical 0.35 of hind tibia, and apical 0.2 of first five tergites bright yellow, the apical yellow fascia of the abdominal terga not reaching their lateral margins; trochanters and the adjacent ends of the femora and coxae yellow to black; hind tarsus fuscous, pale at the base and at the incisures; apical segment of fore and middle tarsi more or less infuscate; wings somewhat smoky, the fore wing quite dark anteriorly.

**Specimens:** ♂, Durham, N. H., July, 1905, J. C. Bridwell (Washington). ♀, Horton, N. Y., July 26, 1935, H. Townes (Townes). ♂, Ithaca, N. Y., July 16, 1935, Victor Tiship (Ithaca). ♀, Ithaca, N. Y., Aug. 3, 1935, Victor Tiship (Townes).

This species has a close superficial resemblance to a small *Philanthus* (such as *P. gibbosus*), *Cerceris*, or *Metopius*. The specimen collected at Horton, N. Y., was taken on the bank of Beaverkill Creek on the flowers of *Pastinaca sativa* in company with many small wasps of generally similar form and color.

### 13. *Monoblastus phaeopteris*, new species

*Wings brown; abdomen fulvous.*

**Male:** Fore wing about 6.5 mm. long; clypeus about 2.2 as wide as long, evenly convex with sparse small punctures all over; face with fine sharp punctures separated by about 3 times their diameter; top of head with a conspicuous swelling just back of the ocelli (this swelling absent in all other species of the genus except *M. melanopteris*); occipital carina incomplete below, not quite reaching the hypostomal carina; hind margin of pronotum a short rounded lobe, slightly elevated; lateral section of prepectal carina straight, ending somewhat above the lower corner of the pronotum; subtegular ridge anteriorly a weak ridge, posteriorly a high carina-like ridge that is up-bowed and somewhat overhanging;

tegula rather strongly convex; nervellus broken at its lower 0.4; tarsal claws pectinate at base; propodeum with fine distinct punctures; costula lacking; lateral carina of propodeum interrupted at the level of the propodeal spiracle (complete in all other species of the genus except *M. melanopteris*); first tergite 1.2 as long as wide, its basal corner not prominent, projecting about as far laterad as the spiracle; second tergite with a distinct postmedian transverse groove and with rather sparse, very fine weak punctures; epipleura of third and fourth tergites apparently represented by very narrow membranous margins to the tergites; spiracle of third tergite separated from margin of tergite by about 3 times its diameter, of the fourth tergite separated by about 4 times its diameter.

Fulvous. In the type, the frons except laterally, occiput, and lower part of thorax and of hind coxa are blackish brown, the darker markings not well defined. In the paratype the meso- and metasterna are largely blackish brown, the rest of the head and body entirely fulvous. Wings brown, the fore wing with an ill-defined subapical paler band.

*Type*: ♂, Cordoba, V. C., Mexico, Dec. 23, 1907, Fredk. Knab (Washington).

*Paratype*: ♂, Hidalgo Co., Tex., June 22, 1933, S. Bromley (Washington).

#### 14. *Monoblastus melanopteris*, new species

*Head, thorax, wings, and legs black; abdomen red.*

*Type male*: Fore wing 6.2 mm. long; occipital carina meeting hypostomal carina at an angle of 50° at 0.8 the basal width of the mandible from its lower end; subtegular ridge rounded, posteriorly somewhat upbowed and overhanging, and ending posteriorly in a high, somewhat overhanging carina; nervellus broken at its lower 0.25; tarsal claws pectinate on basal 0.6; propodeum practically impunctate; first tergite 1.1 as long as wide, its basal corners prominent, projecting distinctly laterad of the spiracles. Agrees otherwise with the structural description of *M. phaeopteris*.

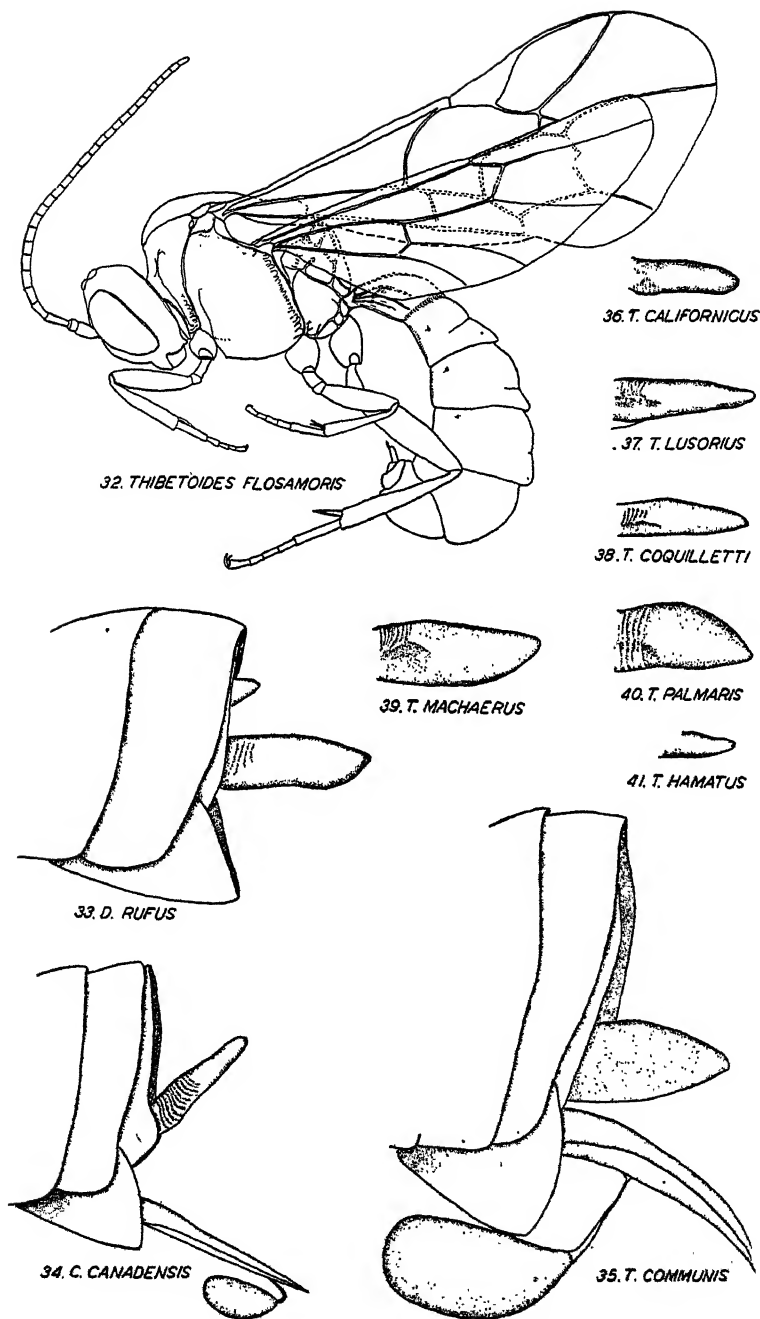
Abdomen red, the rest of the insect black, including the wings. Clypeus, mandible, and posterior half of thorax with vague ferruginous tinges.

*Type*: ♂, Baruta, D. F., Venezuela, Aug. 7, 1938, G. V. Berthier (Townes).

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#### EXPLANATION OF PLATE IV

FIG. 32. *Thibetoides flosamoris* ♀, side view. FIG. 33. *Dyspetus rufus* ♀, end of abdomen. FIG. 34. *Cosmoconus canadensis* ♀, end of abdomen. FIG. 35. *Tryphon communis* ♀, end of abdomen. FIG. 36. *Tryphon californicus*, ovipositor sheath. FIG. 37. *Tryphon lusorius*, ovipositor sheath. FIG. 38. *Tryphon conquitelli*, ovipositor sheath. FIG. 39. *Tryphon machaerus*, ovipositor sheath. FIG. 40. *Tryphon palmaris*, ovipositor sheath. FIG. 41. *Tryphon hamatus*, ovipositor sheath.



Genus *Thibetoides*

## Figure 32

*Thibetoides* Davis, 1897. Trans. Amer. Ent. Soc. 24: 205. Type: *Thibetoides flosamoris* Davis. Monobasic.

*First and second tergites ankylosed. Western United States.*

Fore wing 4.5 to 5.0 mm. long; body very short and stout; clypeus weakly convex with the median apical part projecting a little, the apical margin with an inconspicuous fringe of setae; cheek about 0.2 as long as the basal width of the mandible; frons with a small median horn just above the antennal sockets; posterior condyles of mandibles separated from each other a little farther than are the eyes at the level of the clypeal foveae; outer face of mandible at its basal 0.2 flat, with large punctures; postero-lateral corner of pronotum incrassate; subtegular ridge a little enlarged; tegula convex; costula joining the petiolar area near its base; areolet present, oblique; second recurrent vein angled at the middle, the upper half more strongly curved than the lower, with two well separated bullae; nervellus broken near its lower 0.3; tarsal claws pectinate on their basal 0.3; second tergite completely fused with the first, though separated from it by a strong groove, coarsely punctate, subapically with a shallow transverse groove, beyond the groove less coarsely punctate; fifth tergite very strongly convex longitudinally, the abdomen beyond it turned under; epipleura differentiated and turned under only on the seventh tergite of the female; ovipositor sheath sublinear, about 0.7 as long as the second tergite; ovipositor decurved, tapered to a sharp point, about 0.3 as long as the abdomen.

*Thibetoides* seems to be a derivative of the genus *Monoblastus*, perhaps of the *philanthoides* species group.

*Thibetoides flosamoris* Davis

## Figure 32

*Thibetoides flosamoris* Davis, 1897. Trans. Amer. Ent. Soc. 24: 205. Type: ♂, Siskiyou Co., Calif. (Washington).

Fore wing about 4.7 mm. long; general shape and structure as shown in fig. 32 and as described for the genus; head, thorax and abdomen rather closely and coarsely punctate.

Black or piceous. Apical 0.55 of clypeus ferruginous; mandible yellow, shading to brownish ferruginous at the apex, its base black; palpi yellowish ferruginous; scape often yellow in front; flagellum more or less stained with ferruginous, paler beneath and apically; pronotum usually with an oblong yellow spot on its upper edge; scutellum yellow; metanotum often yellow; wings slightly infumate to nearly hyaline; coxae and trochanters piceous, more or less yellow beneath; femora and tibiae yellow, the apical 0.2 of the hind tibia brown; tarsi yellowish basally, darker apically; apical 0.25 of second to fifth tergites yellow.

*Specimens:* ♀, Arrowhead, San Bernadino Co., Calif., June 3, 1928, E. C. VanDyke (San Francisco). ♀, Bair's Ranch, Redwood Creek, Humboldt Co., Calif., June 12, H. S. Barber (Washington). ♀, Fort Seward, Calif., May 27, 1935, E. W. Baker (Townes). 5 ♂, Yosemite Park at 6,200 ft., Calif., July 22 and 25, 1948, H., M., G., D., & J. Townes (Townes). ♀, Corvallis, Oreg., Sept. 3, 1925, D. A. Wilbur

(Washington). ♂, Glendale, Oreg., Sept. 9, 1897, A. P. Morse (Townes). ♀, Soda Springs, Benton Co., Oreg., June 21, 1943, G. R. Ferguson (Townes). ♂, Spokane, Wash., July 2, 1917, H. S. Dyar (Washington).

This species seems restricted to Washington, Oregon, and the northern and mountainous parts of California. The specimens from Yosemite Park were swept from shaded herbage at the edges of meadows.

## Genus *Chiloplatys*

For figures, refer to the original description

*Chiloplatys* Townes and Townes, 1945. Bol. Ent. Venez. 4: 51. Type: *Chiloplatys lucens* Townes. Monobasic.

*Clypeus very large, in profile almost flat; junction of occipital and hypostomal carinae raised as a tooth. Mexican.*

Fore wing about 5.0 mm. long; body and legs rather slender, the body polished and practically impunctate; clypeus large, its longitudinal convexity very weak so that its profile is almost flat, the median 0.3 of its apical margin with a fringe of closely spaced, parallel setae; cheek about 0.3 as long as the basal width of the mandible; posterior condyles of mandibles separated farther from each other than are the eyes at the level of the clypeal foveae; outer face of mandible at its basal 0.2 moderately convex, punctate; junction of occipital and hypostomal carinae elevated as a triangular tooth; basal flagellar segments very long; postero-lateral corner of pronotum with a rather long and prominent, rounded apical lobe; notaulus absent; subtegular ridge sharp, but not prominent; tegula convex; areolet absent or partly closed by a trace of the second intercubitus; second recurrent vein rather straight, with the two bullae almost or quite confluent; nervellus broken at its lower 0.40 to 0.45; tarsal claws pectinate on their basal 0.33 to 0.75; second tergite smooth, polished, impunctate; ovipositor sheath narrowly linear, about 1.25 as long as the apical depth of the abdomen; ovipositor straight, about 0.5 as long as the abdomen.

*Chiloplatys* seems to be an offshoot of *Monoblastus*. At present it is known only from Mexico.

### KEY TO THE SPECIES OF CHILOPLATYS

1. Face almost flat, but with a small median tubercle just below the antennal sockets; hind femur ferruginous; clypeus with its apical third ferruginous; apical tergites ferruginous; tarsal claws pectinate on their basal 0.75,
  1. *mexicanus*
- Face with a large median elongate mound; hind femur castaneous; clypeus entirely black; apical tergites black with their apical edges more or less stramineous; tarsal claws pectinate on their basal 0.33.....2. *lucens*

#### 1. *Chiloplatys mexicanus* Cresson

*Tryphon mexicanus* Cresson, 1874. Proc. Acad. Nat. Sci. Philadelphia, 25: 391.

Type: ♂, Mirador, Mexico (Philadelphia).

*Chiloplatys mexicanus* Townes, 1946. Bol. Ent. Venez. 5: 40. Generic position.

*Male*: Fore wing about 5.5 mm. long; body and legs a little less slender than in *Chiloplatys lucens*; face evenly, weakly convex, with a small median tubercle just below the antennal sockets; upper part of

face with moderately close punctures; brachiella present as a short stub; tarsal claws strongly pectinate on their basal 0.75.

Black. Ferruginous as follows: mandible, palpi, apical third of clypeus, scape, pedicel, under side of flagellum basally (median and apical part missing), posterior corner of pronotum, tegula, legs, and abdomen except the basal 0.88 of first tergite, basal 0.7 of second tergite, a basal infuscation on the third tergite, and a faint basal infuscation of the fourth tergite. Mandible except apically, posterior corner of pronotum, tegula, trochanters, and front and middle coxae paler ferruginous than the rest; hind tibia and tarsus somewhat infuscate.

*Specimen*: ♂, Guadalajara, Mexico, July 21, McClendon (Philadelphia). Described from this specimen, which was compared with the type.

## 2. *Chiloplatys lucens* Townes

For figures, refer to the original description

*Chiloplatys lucens* Townes and Townes, 1945. Bol. Ent. Venez. 4: 52. Type: ♀, Tancitaro, Tancitaro, Michoacan, Mexico, 6,586 ft. (Townes).

*Female*: Fore wing 4.7 mm. long; body and legs very slender; face with a large median longitudinal mound, its upper part with rather sparse, fine punctures; brachiella absent (erroneously figured as present in the original description); tarsal claws pectinate on their basal 0.33.

Black. Mouthparts, trochanters, fore and middle coxae, apical margin of first three tergites, median part of apical margin of fourth and following tergites, basal margin of second and third tergites, epipleura of fourth and following tergites, and subgenital plate stramineous; scape, pedicel, posterior corner of pronotum, tegula, fore and middle femora and tibiae, and fore tarsus pale ferruginous brown; flagellum basally light brown, the rest black; collar of pronotum indefinitely margined with light brown; hind coxa stramineous with a light brown dorso-lateral stripe; hind femur, tibia, tarsus, and middle tarsus brown.

*Specimen*: Redescribed from the type female from Tancitaro Tancitaro, Michoacan, Mexico, Aug. 15, 1940, Harry Hoogstraal. (Townes).

## *Scolomus*, new genus

Figure 43

Type: *Scolomus viridus*, new species.

*Coloration black and green; areolet broadly sessile above. Patagonian.*

Fore wing about 8.0 mm. long; body moderately stout as shown in fig. 43; clypeus evenly convex, its apical margin truncate, thin, without a fringe of setae; cheek about 1.33 as long as the basal width of the mandible; posterior mandibular condyles separated by a distance a little greater than that between the eyes at their closest point; outer face of mandible at its basal 0.2 convex, with a very few small punctures; occipital carina incomplete below; postero-lateral corner of pronotum not incrassate nor projecting; anterior part of subtegular ridge with a large, laterally projecting thorn; tegula convex; areola elongate pentagonal, its posterior side incomplete; basal area obliterated by the approximation of the median longitudinal carinae, which are high at this level; lateral propodeal carina high and incrassate above the

spiracle and at its junctures with the transverse carinae; areolet pentagonal, broader than high, its upper side the shortest; intercubital veins of equal length, equidistant from the second recurrent vein; second recurrent vein angled at the middle, with a single broad bulla; nervellus broken at its lower 0.2; last segment of tarsi very large, curved; tarsal claws very large, with a right angle bend at the middle, very broad basally, not pectinate except perhaps at the extreme base; dorsal and dorso-lateral carinae of first tergite represented by broad weak ridges; second tergite smooth, polished, impunctate. Female unknown.

In spite of its many aberrant characters, *Scolomus* is closely related to *Dyspetus*. It contains a single Patagonian species.

### *Scolomus viridis*, new species

Figure 43

*Male*: Fore wing 8.0 mm. long; general shape and structure as shown in fig. 43 and as described for the genus; head, prothorax, mesonotum, and mesosternum rather closely punctate; mesopleurum polished and sparsely punctate; metapleurum rugulose; propodeum polished, impunctate; abdomen polished, impunctate.

Blackish. Coxae, trochanters, femora, tibiae, and first three tergites pea green, the tibiae brownish at the apex; tarsi and tibial spurs brown; wing membrane distinctly brownish.

*Type*: ♂, Chubut, Patagonia, from W. F. H. Rosenberg (Washington).

This is one of the very few green ichneumonids. Other green species are the Neotropic (*Neotheronia*) *Theronia lineata pectoralis* Krieger (new combination), and an undescribed Patagonian mesochorine. *Meteorus australis* is a Patagonian braconid with the same black and green color pattern as *Scolomus viridis*.

### Genus *Dyspetus*

Figure 33

*Dyspetus* Thomson, 1883. Opusc. Ent. 9: 899. Type: (*Tryphon praerogator* Gravenhorst) = *Dyspetus fracticeps* Townes.

*Head, as seen from above, with a more or less distinct median notch in the occiput; areolet rhombic, longer than high.*

Fore wing about 7.0 to 8.5 mm. long; body of medium build; clypeus broad, its basal and apical halves meeting across the middle in a low transverse elevation; apical margin of clypeus without a fringe of setae; cheek about 0.5 as long as the basal width of the mandible; posterior mandibular condyles separated from each other by a distance greater than that between the eyes in the lower third of the face; eyes subparallel within or somewhat divergent below; as seen from above, the back of the head with a more or less distinct median notch; posterolateral corner of pronotum not incrassate nor projecting; subtegular ridge high and sharp; tegula convex; areola and basal areas confluent but with a constriction at their juncture; propodeal carinae sometimes subobsolete; areolet rhombic, longer than high, with a very short petiole above, receiving the second recurrent vein near its middle;



second recurrent vein almost straight, with two well separated bullae; nervellus broken at about its lower 0.43; tarsal claws pectinate on about their basal 0.3; median dorsal carinae of first tergite represented by low rounded ridges; dorso-lateral carina of first tergite sharp to about the spiracle, beyond which it is obsolescent; second tergite punctate, with postmedian and sublateral impressions that bound a median swollen area; ovipositor sheath rather flat, somewhat decurved, flexible near the base, about 0.45 as long as the apical depth of the abdomen; ovipositor decurved.

*Dyspetus* seems closely related to *Scolomus* and more distantly to *Monoblastus* and *Cosmoconus*.

*Dyspetes*, rather than *Dyspetus*, is the usual name for this genus. *Dyspetes* was proposed by Foerster in 1868, without included species. Jacobs and Tosquinet (1890, Ann. Ent. Soc. Belg. 34: 93) included the first species, *Ichneumon praerogator* Linnaeus. Roman (1932, Ent. Tidskr. 53: 10) examined the type of *Ichneumon praerogator* Linnaeus and found it to represent a species of "*Angitia*" (= *Horogenes*), rather than a tryphonine as usually considered. *Dyspetes* is consequently a synonym of *Horogenes*, and *Dyspetes praerogator* of authors is without a name. Therefore, *Dyspetus* is used as the only available name for the present genus of Tryphonini and the name *Dyspetus fracticeps* is hereby proposed to replace *Dyspetes praerogator* of authors. Its type is a female in the Townes collection with ferruginous hind femur, collected Sept. 3, 1883, at Erfurt, Germany. It fits the description of *Dyspetes praerogator* given by Schmiedeknecht (1912, Opusc. Ichneum., p. 2360).

### *Dyspetus rufus* Provancher, new combination

Figure 33

*Exetastes rufus* Provancher, 1874. Nat. Canad. 6: 78. Type: ♀, Cap Rouge?, Quebec (Quebec museum).

*Female:* Fore wing about 8.2 mm. long; median notch in back of occiput rather shallow and indistinct; meso- and metapleura with rather coarse punctures separated by about 1.3 their diameter; propodeum polished, with a few indistinct punctures, its carinae high and sharp; areolet receiving second recurrent vein a little basad of its middle; second tergite with weak punctures separated by about 1.5 their diameter; ovipositor sheath rather flat (fig. 33).

Ferruginous. Apical 0.4 of flagellum, fore and middle tibiae, and all tarsi fulvous yellow; hind femur, apical 0.25 of hind tibia, and areas on thorax infuscate.

*Specimen:* Described from a female without locality data (Washington museum) that was taken from Provancher's collection by Gahan in 1916, and at that time compared with the lectotype. The species seems known only from Provancher's series that was taken in Quebec, probably at Cap Rouge.

### Genus *Cosmoconus*

Figure 34

*Cosmoconus* Foerster, 1868. Verh. Naturh. Ver. Preuss. Rheinlande 25: 203. Type: *Ichneumon elongator* Fabricius. Included by Woldstedt 1877.

*Frons with a median tubercle or cylindric horn; cheek 0.4 to 0.9 as long as the basal width of the mandible; Nearctic species black and yellow.*

Fore wing 6.0 to 9.0 mm. long; body of medium build; clypeus rather broad, its basal and apical parts meeting in a more or less distinct submedian transverse ridge; apical margin of clypeus with a fringe of short setae; cheek about 0.4 to 0.9 as long as basal width of mandible; posterior mandibular condyles separated from each other by a distance a little greater than that between the eyes; outer face of mandible at its basal 0.2 flat, punctate; frons with a median horn varying from a low tubercle to long and finger-like; postero-lateral corner of pronotum incrassate and projecting; subtegular ridge heavy and rather sharp; tegula flat above; areolet petiolate or subpetiolate above, subrhombic, the second intercubitus a little longer than the first and nearer than the first to the second recurrent vein; second recurrent vein with a sinuation or angulation just above the middle, but otherwise straight, with a single broad bulla or with two narrowly separated bullae; nervellus broken at its lower 0.35 to its upper 0.45; tarsal claws usually pectinate only basally but sometimes pectinate on their basal 0.67; second tergite smooth, polished, with numerous small weak punctures; ovipositor sheath narrow, its apical half convex and rigid, its basal half flatter, a little broader, and somewhat flexible (fig. 34); ovipositor weakly downcurved or nearly straight, tapered to a sharp point (fig. 34).

*Cosmoconus* seems nearest to *Dyspetus*, but is not very different from *Tryphon*.

The American species of *Cosmoconus*, all Nearctic, occur among rank herbage in open moist woods, along the edges or in small clearings of denser woods, or among rank unshaded shrubbery and herbage. Their bright coloration makes them conspicuous. Certain species of *Mesoleius* occur in the same habitats and have habits, size, shape, and coloration very similar to the species of *Cosmoconus*. *Mesoleius vanconverensis* is similar to and occurs with *C. arcticus*, while *Mesoleius nigropictus* is similar to and occurs with *C. canadensis*.

#### KEY TO THE AMERICAN SPECIES OF COSMOCONUS

1. Frontal horn 0.8 to 3.0 as long as its basal diameter, cone-shaped or finger-shaped; tarsal claws of female pectinate on their basal 0.65 =; fourth tergite entirely yellowish; thorax more strongly and more closely punctate. Alaska and west of the Rocky Mountains. . . . . 1. *arcticus*  
 Frontal horn not more than 0.5 as long as its basal diameter, a weak tubercle or often almost lacking; tarsal claws of female pectinate on their basal 0.35 =; fourth tergite more or less black or fuscous; thorax less strongly and less closely punctate; east of the Rocky Mountains. . . . . 2
2. Middle femur of female more or less black; hind coxa of male with more than the basal 0.6 black; cheek about 0.57 as long as the basal width of the mandible; costula usually strong; Canadian and Transitional zones, . . . . . 2a. *canadensis canadensis*  
 Middle femur of female entirely yellowish; hind coxa of male with less than its basal 0.4 black; cheek about 0.47 as long as the basal width of mandible; costula usually weak or absent; Transitional and Upper Austral zones, . . . . . 2b. *canadensis vallis*

#### 1. *Cosmoconus arcticus* Brues

*Polyblastus arcticus* Brues, 1919. Canad. Arctic Exped. 1913-18, 3 G: 22. Type: ♀, Ketchikan, S. Alaska (Ottawa).

*Frontal horn 0.8 to 3.0 as long as its basal diameter.*

Fore wing about 8.0 mm. long; cheek about 0.6 as long as the basal

width of the mandible; frontal horn conical to finger-shaped, 0.8 to 3.0 as long as its basal diameter; thorax more strongly sculptured than in *C. canadensis*; mesopleurum with rather strong dense punctures, its lower posterior part usually with rugae between the punctures; costula strong; tarsal claws of female pectinate on their basal  $0.65\pm$ .

Colored as in *C. canadensis* except as follows: apical part of first tergite, all of second, third, and fourth tergites and all to none of the fifth tergite yellow to fulvous; front and middle femora of both sexes entirely yellowish.

*Specimens*: ♂, Hunters Bay, Alaska, collected by Wickam (Washington). ♂, Juneau, Alaska, July 25, 1899, T. Kincaid (Townes). ♂, Ketchikan, Alaska, Aug. 7, 1919, H. G. Dyar (Townes). ♀, Muir Woods, Marin Co., Calif., May 19, 1915, M. C. VanDuzee (San Francisco). 3 ♂, ♀, Cannon Beach, Oreg., Aug. 11, 1940 (H. & M. Townes (Townes). ♂, Forest Grove, Oreg., June 3, 1918, M. C. Lane (Washington). ♀, Prospect, Oreg., June 20, 1924, C. L. Fox (San Francisco). 15 ♂, ♀, Seaside, Oreg., Aug. 10, 1940, H. & M. Townes (Townes, Washington, Lawrence, W. W. Baker, R. L. Furniss, and Philadelphia). ♀, Smith River, Douglas Co., Oreg., Sept. 14, 1932, D. K. Frewing (Washington). 2 ♂, Ashford, Wash., July 6, 1940, H. & M. Townes (Townes). ♀, Elbe, Wash., July 25, 1940, H. & M. Townes (Townes). 5 ♂, ♀, Mt. Rainier, Wash., July 2, 1940, at 2,900 ft. and Aug. 13, 1940, at 2,700 ft. and 4,700 ft., H. & M. Townes (Townes); ♀, Wash., July 23, 1893, T. Kincaid (Ithaca); ♀, "QCI" (Ottawa). ♀, no locality, D. A. Wilbur (Washington).

## 2. *Cosmoconus canadensis* Provancher

### Figure 34

*Frontal horn not more than 0.5 as long as its basal diameter.*

Fore wing about 6.0 to 8.5 mm. long; frontal horn a low rounded tubercle or sometimes absent, never more than 0.5 as long as its basal diameter; mesopleurum moderately, rather closely punctate; costula strong, weak, or absent; tarsal claws of female pectinate on their basal  $0.35\pm$ .

Black. Yellow or yellowish fulvous as follows: palpi, clypeus, face, tegula, postero-lateral corner of pronotum, bases of wings, all of third tergite, more or less of the apical part of the first tergite, and usually most of the second tergite. When the second tergite is not entirely yellowish, it has a broad transverse median black band which is often more or less interrupted in the middle. Frequently more or less of the basal part of the fourth tergite is yellowish and sometimes all but an apical band is yellowish. Legs yellow and black, the amount of yellow depending on the subspecies. The face of the female frequently has an indefinite dark median stripe and the upper 0.4 of the female clypeus is also frequently darkened. The antenna is blackish brown, more or less yellowish or fulvous toward the base and apex, especially below.

This species occurs in the Canadian, Transitional, and Upper Austral zones of the eastern and central United States and Canada. It is represented by the two subspecies described below.

2a. *Cosmoconus canadensis canadensis* Provancher

*Tryphon Canadensis* Provancher, 1875. Nat. Canad. 7: 117. Type: ♀, Que. (Quebec).

Fore wing about 7.5 mm. long; cheek about 0.57 as long as the basal width of the mandible; costula usually strong, sometimes weak or absent. The general sculpture of this subspecies is a little stronger than in *C. canadensis vallis*.

Legs yellowish, black as follows: coxae except often at their apices (the hind coxa usually entirely black, never with less than its basal 0.6 black); hind femur except at the extreme base; middle femur of female except for a narrow basal and a broad apical part; often more or less of the fore femur of the female; and the basal 0.1 and apical 0.35 of the hind tibia. Sometimes the middle femur and rarely the fore femur of the male are marked with black as in the female.

*Specimens:* Many males and females from COLORADO (Steamboat Springs); MAINE (Fort Kent and Orr's Island); MASSACHUSETTS (Mt. Greylock); MICHIGAN (Kalkaska Co.); MINNESOTA (Itasca, Itasca Park, Lake Superior Shore in Rosebush Township, and Sawyer Co.); MISSOURI (Columbia); NEW BRUNSWICK (St. John and Shediak); NEW HAMPSHIRE (Gorham and Randolph); NEW YORK (Adirondack Mountains, Bemus Point, Boreas River in Essex Co., Breesport, East Aurora, Hancock, Ithaca, Oliveira, Onteora Mt. in Greene Co., Saranac Lake, and Westville); NORTH CAROLINA (Clingman's Dome at 6,600 ft. and Whiteside Mt. near Highlands at 4,730 ft.); NOVA SCOTIA (Baddeck); ONTARIO (Constance B., Emsdale, Palmer Rapids, and Pelee Island); PENNSYLVANIA (Ganoga Lake in Sullivan Co. and Mt. Holly Springs); QUEBEC (Aylmer, Brome, Cascapedia, Granby, Ile d'Orleans, Kazubazua, Knowlton, Lac Mercier, Lanoraie, Quebec, St. Agathe des Montes, and Sutton); SASKATCHEWAN ("Y Grass"); VIRGINIA (Skyline Drive); and VERMONT (Rutland and Stowe).

This subspecies occurs in the Canadian Zone of the eastern half of the continent with some overlap into the Transitional Zone. Ordinarily it is not found south of New York but in the mountains extends to southern North Carolina. Adults have been captured from June 8 (Columbia, Mo.) and June 10 (Quebec, Que.) to September 10 (Sullivan Co., Pa.), but most records fall between July 15 and August 29, indicating a single generation emerging mostly in July and staying on the wing into early September.

2b. *Cosmoconus canadensis vallis*, new subspecies

Fore wing about 6.5 mm. long; cheek about 0.47 as long as the basal width of the mandible; costula usually weak or absent. The general sculpture of this subspecies is slightly weaker than in *C. canadensis canadensis*.

Colored as in *C. canadensis canadensis* except as follows: fore and middle legs of male entirely yellowish and in the female entirely yellowish except that their femora are fulvous and their coxae basally infusate; hind coxa of the male yellow with the base black or infusate, at least the apical 0.6 entirely yellow; hind coxa of female blackish with about the apical 0.3 fulvous.

*Type:* ♀, on Northwest Branch at University Lane bridge, Takoma Park, Md., June 14, 1942, H., M., & G. Townes (Townes).

*Paratypes:* ♀, southern Illinois, collected by Robertson (Washington). ♂, ♀, Iowa (Washington). ♂, Ames, Iowa (Washington). ♂, Bowie, Md., May 30, 1945, H. & M. Townes (Townes). ♂, ♀, Bowie, Md., May 30, 1945, H. Townes (Washington). ♂, ♀, Takoma Park, Md., June 6 and 7, 1942, H. & M. Townes (Townes). ♀, collected with the type (Townes). ♀, Laval Co., Que., June 29, 1902 (Ithaca). ♂, Dallas, Tex., July 10, 1907, R. A. Cushman (Townes). ♀, no data (Washington).

The specimens taken in Maryland were from the rank undergrowth of moist bottomland woods.

### Genus *Tryphon*

Figures 35 to 42 and 44 to 48

*Second recurrent vein with a strong zigzag; cheek about 0.15 as long as the basal width of the mandible. Holarctic.*

Fore wing 4.0 to 9.0 mm. long; body stout; clypeus broad, its basal and apical sections meeting at a transverse ridge; apical margin of clypeus with a fringe of short setae; cheek about 0.15 as long as the basal width of the mandible; posterior mandibular condyles separated from each other farther than are the eyes at the level of the clypeal foveae; outer face of mandible at its basal 0.2 flat, rather densely punctate; postero-lateral corner of pronotum incassate, projecting; subtegular ridge heavy, usually angular (figs. 44 to 48); tegula flat or weakly convex above; areolet petiolate, subtriangular, receiving the second recurrent vein from near the middle to subapically (fig. 42); second recurrent vein with one broad bulla or with two bullae separated by a small sclerotized area, strongly zigzagged (fig. 42); nervellus broken between its lower 0.3 and its upper 0.4; tarsal claws pectinate only at the extreme base; second tergite smooth, variously sculptured; ovipositor sheath finger-shaped to quite broad, about 0.6 as long as the apical depth of the abdomen, its basal part flexible (figs. 35 to 42); ovipositor decurved or straight, tapered to a sharp point (fig. 35).

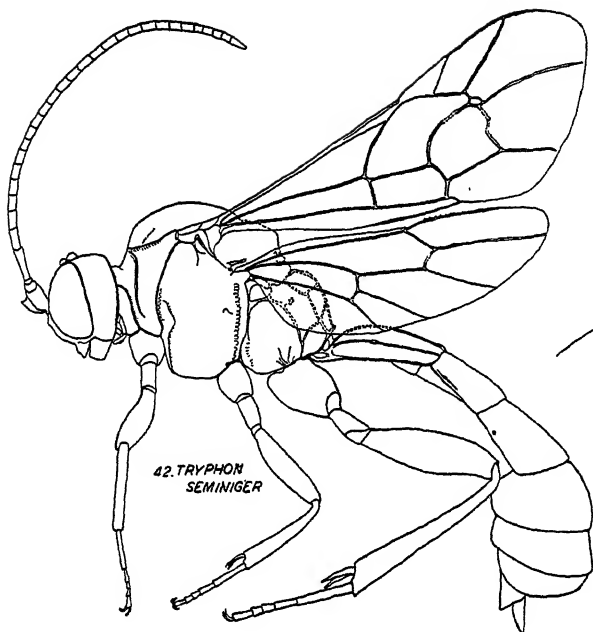
*Tryphon* is most closely related to *Cosmoconus* and *Dyspetus*. It is divisible into three subgenera.

#### KEY TO THE SUBGENERA OF TRYPHON

1. Outer half of apical margin of hind tibia extending beyond the insertion of the spurs by about 0.5 the length of the spurs; outer apical margin of front tibia produced into a prominent tooth; central part of face rather sharply elevated and set off as a distinct area. Californian. . . . Subgenus *Nëomon*
- Outer half of apical margin of hind tibia extending beyond the insertion of the spurs by 0.2 to 0.35 the length of the spurs; outer apical margin of front tibia rarely produced as a small tooth, usually not produced; central part of face not set off as a distinct area. . . . . 2

#### EXPLANATION OF PLATE V

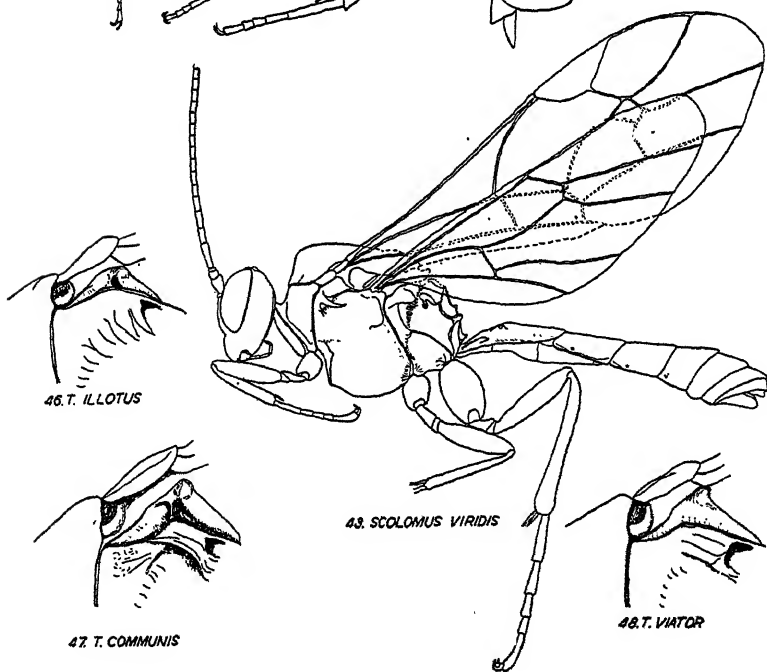
FIG. 42. *Tryphon seminiger* ♀, side view. FIG. 43. *Scolomus viridis* ♂, side view. FIG. 44. *Tryphon tempeli*, subtegular ridge. FIG. 45. *Tryphon humeralis*, subtegular ridge. FIG. 46. *Tryphon illotus*, subtegular ridge. FIG. 47. *Tryphon communis*, subtegular ridge. FIG. 48. *Tryphon viator*, subtegular ridge.



44. *T. REMPELI*



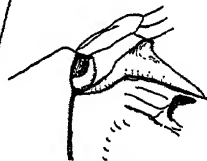
45. *T. HUMERALIS*



46. *T. ILLOTUS*



47. *T. COMMUNIS*



48. *T. VIATOR*

2. Area between posterior condyle of mandible, lower end of occipital carina, and hypostoma carina projecting from the condyle mesad by at least 0.3 the basal width of the mandible, often somewhat impressed; transverse ridge of clypeus at about the basal 0.3; upper margin of antennal socket frequently double, with the upper section usually produced as a crescentic flange. Palaearctic. . . . . Subgenus *Tryphon*
- Area between posterior condyle of mandible, lower end of occipital carina, and hypostomal carina projecting mesad from the condyle by less than 0.3 the basal width of the mandible; transverse ridge of clypeus at or somewhat basad of the middle; upper margin of antennal socket never double though sometimes produced and modified. Holarctic. . . . . Subgenus *Symboëthus*

### Subgenus *Noëmon*

Figures 36 to 41

*Noëmon* Foerster, 1868. Verh. Naturh. Ver. Preuss. Rheinlande, 25: 207. Type: *Noëmon palmaris* Davis. Designated by Viereck 1914.

Central part of face rather sharply elevated and set off as a distinct area; apical and basal sections of clypeus meeting in a transverse ridge that is at its basal 0.2 to 0.35; apical margin of clypeus with a sparse fringe of short, rather slender setae; area between posterior mandibular condyle, lower end of occipital carina, and hypostomal carina produced mesad from the condyle by less than 0.3 the basal width of the mandible, not impressed; upper part of rim of antennal socket simple; tegula weakly convex above, outer apical margin of front tibia produced as a strong tooth; outer half of apical margin of hind tibia produced beyond the sockets of the tibial spurs by about 0.5 the length of the spurs.

All of the six known species are Californian. The relationships between them are not clear. *Hamatus* stands apart in several unique characters. The other five differ among themselves in the punctuation of the face, of the mesopleurum, of the propodeum, of the petiole, and in having the apical part of the ovipositor sheath either strongly or weakly convex. These characters do not seem to correlate enough to give an adequate basis for grouping the species.

#### KEY TO THE SPECIES OF THE SUBGENUS NOËMON

1. Face entirely black. . . . . 2
- Face partly or entirely yellow. . . . . 3
2. Hind tibia externally fusco-ferruginous, elsewhere ferruginous; raised central part of face with coarse punctures separated by more than their diameter; ovipositor sheath of almost uniform width to near its bluntly rounded apex (fig. 36). . . . . 1. *californicus*
- Hind tibia externally yellow, elsewhere ferruginous; raised central part of face with moderately coarse punctures separated by less than their diameter; ovipositor sheath tapered evenly from its base to the bluntly pointed apex (fig. 37). . . . . 2. *lusorius*
3. Face entirely yellow; dorsal carinae of first tergite extending about 0.6 its length; lateral and sublateral sections of apical propodeal carina interstitial at the lateral longitudinal carina. . . . . 6. *hamatus*
- Face black with one or a pair of large yellowish spots on its raised central part; dorsal carinae of first tergite extending about 0.25 its length; lateral and sublateral sections of apical propodeal carina not interstitial at the lateral longitudinal carina. . . . . 4
4. Central raised part of face with about 50 coarse punctures; third segment of hind tarsus about 2.2 as long as wide; apical part of ovipositor sheath strongly convex. . . . . 5. *palmaris*
- Central raised part of face with about 150 medium sized punctures; third segment of hind tarsus less than 2.0 as long as wide; apical part of ovipositor sheath weakly convex. . . . . 5

5. Ovipositor sheath narrow (fig. 38), its apical part tapered symmetrically from above and below; hind tibia with a conspicuous external yellow stripe.....3. *coquilletti*  
 Ovipositor sheath broader (fig. 39), its apical part tapered much more strongly from below than from above; hind tibia without a conspicuous external yellow stripe.....4. *machaerus*

### 1. *Tryphon* (Noëmon) *californicus* Cresson

Figure 36

*Tryphon californicus* Cresson, 1878. Proc. Acad. Nat. Sci. Phila., p. 373. Type: ♀, San Diego, Calif. (Philadelphia).

*Face black; hind tibia externally fusco-ferruginous, elsewhere ferruginous.*

Fore wing about 4.3 mm. long; transverse ridge of clypeus at its basal 0.23, beyond which there is a weakly impressed transverse groove; raised central part of face rather coarsely punctate, with about 50 punctures; punctures on mesoscutum separated by about 1.5 their diameter; mesopleurum with medium sized punctures separated by about 1.5 their diameter; fused first and second lateral areas of propodeum with conspicuous medium sized puncture; first tergite with rather close medium sized punctures, in male about 1.5 as long as wide and in female about 1.2 as long as wide, its dorsal carinae extending about 0.25 its length; third segment of hind tarsus about 2.8 as long as wide; ovipositor sheath shaped as in figure 36, its apical part strongly convex.

Black. Clypeus fulvous, narrowly blackish across the base; mandible yellow, apically ferruginous; palpi brown, the apical three segments of the maxillary palpus yellow; tegula yellow; legs beyond first trochanters ferruginous, more or less infuscate on the basal part of the fore and middle femora, apex of hind femur, the hind tarsus, and slightly on the middle tarsus; front and middle tibiae paler externally; hind tibiae slightly infuscate externally; apical 0.25 to 0.1 of first tergite and all of the following tergites ferruginous, or sometimes more or less infuscate.

*Specimens:* 2 ♂, 2 ♀ (including the type ♀) from California (Philadelphia).

### 2. *Tryphon* (Noëmon) *lusorius* Cresson

Figure 37

*Tryphon lusorius* Cresson, 1878. Proc. Acad. Nat. Sci. Phila., p. 373. Type: ♂, Calif. (Philadelphia).

*Face black; hind tibia externally yellow, elsewhere ferruginous.*

Fore wing about 5.4 mm. long; transverse ridge of clypeus at its basal 0.24, beyond which there is a weakly impressed transverse groove; raised central part of face with about 120 moderately coarse punctures; punctures on mesoscutum separated by about 1.4 their diameter; mesopleurum with medium sized punctures separated by about 1.5 their diameter; fused first and second lateral areas of propodeum with conspicuous punctures; first tergite with rather close medium sized punctures, about 1.5 as long as wide, its dorsal carinae extending about 0.25 its length; glymma of first tergite practically absent (distinct in other species of the genus); third segment of hind tarsus about 2.6 as



long as wide; ovipositor sheath shaped as in figure 37, its apical part weakly convex.

Black. Apical part of flagellum fulvous beneath; clypeus fulvous to ferruginous, black basad of its transverse ridge; mandible yellowish, dark ferruginous apically; palpi brown, the apical three segments of the maxillary palpus yellowish; fore and middle legs beyond the first trochanters yellowish, the basal ventral part of their femora more or less blackish; hind leg beyond the first trochanter ferruginous, its second trochanter yellow but infusate ventrally, its femur with a basal ventral and a smaller apical dorsal infusate area, its tibia apically and its tarsus except at the joints infusate, and its tibia with a broad yellow stripe extending from its base to near the apex; apical 0.1 to 0.25 of first tergite and the rest of the tergites ferruginous.

*Specimens:* 2 ♂, ♀ (including the male type) from southern California (Philadelphia). ♀, Mt. Diablo, Calif., April 20, 1935, Bohart (Townes). ♀, Mt. Hamilton, Calif., June 2, 1933, Bohart (Townes). ♂, Lancaster, Calif., March 14, 1935, A. L. Melander (Cambridge).

### 3. *Tryphon* (Noëmon) *coquilletti*, new species

Figure 38

*Face centrally marked with yellow; hind tibia with a conspicuous external yellow stripe.*

Fore wing about 4.6 mm. long; transverse ridge of clypeus at its basal 0.23, beyond which the clypeus has no impressed transverse groove but is flat in profile; raised central part of face with about 150 medium sized punctures; punctures on mesoscutum separated by about 1.3 to 3.0 their diameter; mesopleurum with rather fine punctures separated by about 1.7 their diameter; fused first and second lateral areas of propodeum finely punctate; first tergite finely and rather closely punctate, about 1.1 as long as wide, its dorsal carinae extending about 0.25 its length; third segment of hind tarsus about 1.8 as long as wide; ovipositor sheath shaped as in figure 38, its apical part weakly convex.

Black. Face with a pair of well separated yellow spots on its central raised portion; clypeus, mandible, and palpi yellow, the mandible ferruginous apically and the palpi brown basally; tegula yellow; front and middle legs with their coxae and trochanters blackish, their femora ferruginous darkening to brownish towards their bases and narrowly yellow at their apices, their tibiae ferruginous internally and yellow externally, and their tarsi ferruginous, somewhat infusate apically; hind coxa, tarsus except on the base of the basitarsus, and first trochanter blackish; second trochanter and hind femur ferruginous, the trochanter somewhat infusate basally and the femur apically; hind tibia ferruginous, infusate basally and apically, and with an external yellow stripe extending from near its base to beyond its middle; apical 0.25 = of first tergite and the rest of the abdomen ferruginous.

*Type:* ♀, Los Angeles Co., Calif., March, D. W. Coquillet (Washington).

*Paratype:* ♀, Paso Robles, Calif., May 1, 1917, E. C. VanDyke (San Francisco).

4. *Tryphon* (Noëmon) *machaerus*, new species

Figure 39

*Raised central part of face more or less yellow, with about 150 punctures; hind tibia without a conspicuous external yellow stripe.*

Fore wing about 5.5 mm. long; transverse ridge of clypeus at its basal 0.2, beyond which there is a weakly impressed transverse groove; raised central part of face with about 150 medium sized punctures; punctures on mesoscutum rather fine, separated by about 2.5 their diameter; mesopleurum with fine sparse punctures separated by about 4.0 their diameter, sometimes very sparse; fused first and second lateral areas of propodeum very finely and sparsely punctate; first tergite with fine punctures, that of the male about 1.4 as long as wide and of the female about 1.2 as long as wide, its dorsal carinae extending about 0.25 its length; third segment of hind tarsus about 1.3 as long as wide; ovipositor sheath shaped as in figure 39, its apical part weakly convex.

Black. Central part of face with an elliptical yellowish fulvous area which is more or less completely vertically divided into a pair of spots; clypeus, mandible, and palpi yellowish fulvous, the mandible dark ferruginous apically and the clypeus blackish on its base; under side of scape light brown; tegula yellow; coxae brown, the fore coxa pale brown and the hind coxa blackish brown; first trochanter some shade of brown; the rest of the legs ferruginous with the apex of the fore and middle femora and the outer side of the fore and middle tibiae yellow and the apical part of the hind tibia and the hind tarsus except for the base of the first segment infusate; base of first tergite black, the rest of the abdomen ferruginous.

*Type:* ♀, Mt. Diablo, Calif., April, 1934, Bohart (Townes).

*Paratypes:* ♂, 5 ♀, southern California (Philadelphia and Townes).

5. *Tryphon* (Noëmon) *palmaris* Davis

Figure 40

*Noëmon palmaris* Davis, 1898. Trans. Amer. Ent. Soc. 24: 287. Type: ♀, southern Calif. (Philadelphia).

*Face with the central raised part more or less yellow, the rest black; central raised part of face with about 50 coarse punctures.*

Fore wing about 6.0 mm. long; transverse ridge of clypeus at its basal 0.25, beyond which there is a moderately impressed transverse groove; raised central part of face with about 50 coarse punctures; punctures on mesoscutum rather fine, separated by about 2.5 their diameter; mesopleurum with fine punctures separated by about 2.5 their diameter; fused first and second lateral areas of propodeum very finely and sparsely punctate; first tergite with fine punctures, that of the male about 1.3 as long as wide and of the female about 1.23 as long as wide, its dorsal carinae extending about 0.25 its length; third segment of hind tarsus about 2.2 as long as wide; ovipositor shaped as in figure 40, its apical part strongly convex.

Coloration as in *Tryphon machaerus*.

*Specimens:* ♂, 8 ♀ (including the female type) from southern California (Philadelphia).

6. *Tryphon* (Noëmon) *hamatus*, new species

Figure 41

*Face entirely yellow.*

Fore wing about 6.0 mm. long; transverse ridge of clypeus at its basal 0.35, beyond which is a strongly impressed transverse groove; raised central part of face with about 50 coarse punctures; punctures on mesoscutum separated by about 2.0 their diameter; mesopleurum with rather fine punctures separated by about 2.0 their diameter; fused first and second lateral areas of propodeum partly incompletely rugose, finely and sparsely punctate; lateral and sublateral sections of apical carina of propodeum interstitial at the lateral longitudinal carina (not interstitial in any other species of *Noëmon*); first tergite with rather fine punctures, about 1.3 as long as wide in the male and 1.35 as long as wide in the female, its dorsal carinae extending about 0.6 its length; third segment of hind tarsus about 2.2 as long as wide; ovipositor sheath shaped as in figure 41, its apical part weakly convex; ovipositor (and its sheath) shorter than in other members of the genus, only about 0.6 as long as the apical depth of the abdomen.

Black. Face, clypeus, under side of scape and pedicel, a stripe on under side of first flagellar segment, mandible, palpi, tegula, apices of coxae, trochanters, outer side of fore and middle tibiae, and apices of fore and middle femora yellow; apical part of mandible and base of maxillary palpus brownish; front and middle legs beyond their trochanters yellowish ferruginous; hind legs beyond trochanters ferruginous with the apical part of the tibia and the median part of the first two tarsal segments infusate; coxae of female ferruginous with the base black and the apex yellow, of male black with the apex yellow.

*Type:* ♀, Herkey Creek, San Jacinto Mts., Calif., May 22, 1939, E. G. Linsley (Townes).

*Paratypes:* ♀, E. Highlands, Calif., "4/14," F. R. Cole (Washington). ♂, Yorkville, Mendocino Co., Calif., May 17, 1929, E. P. Van Duzee (San Francisco). ♀, Mt. Hamilton at 3,000 to 4,000 ft., Calif., June 2, 1933, M. Cazier (Corvallis).

Subgenus *Tryphon*

*Tryphon* Fallén, 1813. Specimen Nov. Hymen. Disp. Method., p. 16. Type:

*Ichneumon rutilator* Linnaeus. Designated by Curtis 1832.

*Psilosage* Foerster, 1868. Verh. Naturh. Ver. Preuss. Rheinlande, 25: 203. New synonymy. Type: *Tryphon ephippium* Holmgren. Included by Morley, 1912.

*Otiotichilus* Foerster, 1868. Verh. Naturh. Ver. Preuss. Rheinlande, 25: 203.

Type: *Tryphon trochanteratus* Holmgren. Designated by Viereck 1914.

Central part of face not set off as a distinct elevated area; apical and basal sections of clypeus meeting in a transverse ridge that is near the basal 0.3 of the clypeus; apical margin of clypeus with a fringe of short setae which is often sparse or ragged, the setae slender in the male and rather slender to stout and peg-like in the female; area between posterior mandibular condyle and lower end of occipital carina projecting mesad from the condyle by more than 0.3 the basal width of the mandible, often somewhat impressed; upper part of rim of antennal socket usually with a crescentic ear-like flange in addition to the normal rim; tegula weakly convex above; outer apical margin of front tibia

not produced as a tooth, or rarely produced as a small tooth; outer half of apical margin of hind tibia produced beyond the sockets of the tibial spurs by 0.2 to 0.35 the length of the spurs.

The species of this subgenus are all Palaearctic. We have examined the following: *auricularis* Thomson 1883, *brunniventris* Gravenhorst 1829, *ephippium* Holmgren 1855, *nigripes* Holmgren 1855, *obtusator* Thunberg 1822, *pleuralis* Thomson 1883, *relator* Thunberg 1822, *rutilator* Linnaeus 1761, *separandus* Schmiedeknecht 1912, *signator* Gravenhorst 1829, *subsulcatus* Holmgren 1855, and *trochanteratus* Holmgren 1855.

### Subgenus *Symboëthus*

Figures 42 and 44 to 48

*Symboëthus* Foerster, 1868. Verh. Naturh. Ver. Preuss. Rheinlande, 25: 204.

Type: *Tryphon exclamatoris* Gravenhorst. Designated by Viereck 1914.

*Quadrigana* Davis, 1897. Trans. Amer. Ent. Soc. 24: 280. Type: *Tryphon americanus* Cresson. Monobasic.

Central part of face not set off as a distinct elevated area; apical and basal sections of clypeus meeting in a transverse ridge that is at or somewhat basad of the middle; apical margin of clypeus with a fringe of short setae, slender in the male and peg-like in the female; area between posterior mandibular condyle and lower end of occipital carina not impressed, projecting mesad from the condyle by less than 0.3 the basal width of the mandible; upper part of rim of antennal socket not double; tegula flat or weakly convex above; outer apical margin of front tibia not produced as a tooth; outer half of apical margin of hind tibia produced beyond the sockets of the tibial spurs by 0.2 to 0.35 the length of the spurs.

This subgenus is Holarctic. Its species may be divided into four groups as follows:

1. *Mystax* group. Unique in having the lateral and sublateral sections of the apical propodeal carina not interstitial at the lateral longitudinal carina. Included are the Nearctic *mystax*, *rempeli*, *alaskensis*, *humeralis*, *communis*, and *illotus* and the European *Tryphon* (*Symboëthus*) *incestus* Holmgren 1855 (new combination) and *Tryphon* (*Symboëthus*) *exclamationis* Gravenhorst 1829 (new combination). Among these, *communis*, *illotus*, and *exclamationis* are aberrant: *communis* has a wide ovipositor sheath, *illotus* a laterally margined scutellum and some other unusual characters, and *exclamationis* with its produced margins of the antennal sockets and rather flat face and narrow clypeus makes a connecting link with the *heliophilus* group.

2. *Heliophilus* group. Lateral and sublateral sections of apical propodeal carina nearly interstitial; subtegular ridge about as in *mystax* group; hair on head and thorax unusually long; clypeus unusually narrow, it and the face flatter than in other groups; upper inner margin of antennal socket produced as a large tooth. The European *Tryphon* *heliophilus* Gravenhorst 1829 is the only species.

3. *Viator* group. Lateral and sublateral sections of apical propodeal carina interstitial, or in *americanus* the propodeum highly modified; subtegular ridge in the form of a lamella with a thin, rather evenly convex margin (fig. 48); entire face evenly convex across the center.

Included are the Nearctic *viator* and *americanus*. *Americanus* has a very peculiar propodeum, which prompted Davis to propose the genus *Quadrigana* for it.

4. *Seminiger* group. Unique in having strong, wing-like lateral carinae on the scutellum, seventh tergite of female very narrow dorsally, and apical part of penis relatively unenlarged; lateral and sublateral sections of propodeal carina interstitial. Included in the Nearctic *seminiger*.

\* In North America, the species of the subgenus *Symboëthus* are widespread and frequently abundant in the Hudsonian, Canadian, and Transitional zones. They appear to be almost totally absent in the Upper Austral and southward. The usual habitat is moist grassy places: along roadside ditches, the borders of and clearings in woods, and in grassy meadows, usually where there is also *Equisetum arvense* growing. All appear to have a single generation per year. They are adult in spring and early summer, or in more northern habitats somewhat later in the season. In the Transitional Zone, most are on the wing by May 15 and have disappeared by June 20. *S. communis* appears about ten days later and it and *S. seminiger* remain later in the summer, in northern localities until late in August.

Their abundance, size, and slow flight among the tops of grass blades make the species of this subgenus easy to collect. Because all have about the same seasonal and ecological distribution, a number of species may be found at the same time and place, yet each occurs in rather well defined colonies. The factors influencing details of distribution of the various species have not been studied, but it has been noted that *S. seminiger* and *S. communis* have more frequently been collected in drier more sunny habitats. No host records are available, though seasonal and ecological distribution indicate that they are all parasites of sawflies of the genus *Dolerus*.

#### KEY TO THE AMERICAN SPECIES OF THE SUBGENUS SYMBOËTHUS

1. Propodeum with the median four longitudinal carinae very high, between which it is polished and impunctate; petiolar area not defined; face of male yellow (*viator* group, in part).....8. **americanus**  
 Propodeum with the median four longitudinal carinae normal, between which it is more or less rugulose or punctate; petiolar area clearly defined.....2
2. Lateral and sublateral sections of apical propodeal carina interstitial or approximately interstitial at the lateral carina.....3  
 Lateral and sublateral sections of apical propodeal carina not interstitial at the lateral carina, the sublateral section meeting the lateral carina far apical of the place at which the lateral section meets it (*mystax* group).....4
3. Scutellum with high lateral carinae extending to its apex; subtegular ridge irregularly shaped, medially with a strong dorsally projecting tooth; seventh tergite of female very narrow above; apical part of penis slightly enlarged, with a thin ventral lamina extending almost to the apex; face irregularly convex, its central 0.3 rather abruptly elevated and somewhat flattened medially (*seminiger* group).....9. **seminiger**  
 Scutellum with lateral carinae only at its basal corners; subtegular ridge projecting upwards as a lamina with its margin rather evenly convex, without a median tooth (fig. 48); seventh tergite of female of normal width above; apical part of penis bulbously swollen and decurved; face evenly convex across the middle (*viator* group, in part).....7. **viator**
4. Scutellum bordered by strong lateral ridges almost to its apex; clypeus entirely black; subtegular ridge rather evenly arched (fig. 46).....6. **illotus**

- Scutellum without lateral ridges except at its basal corners; clypeus yellow or fulvous at least in part; subtegular ridge irregularly shaped (figs. 44, 45, and 47)..... 5
5. Ovipositor sheath about 0.7 as wide as hind femur and 2.0 as long as wide (fig. 35); median elevated quadrangular section of subtegular ridge with more or less distinct fine oblique ridges which do not enclose a depression (fig. 47); central 0.75 of face elevated as a low flattened mound; face of male entirely black or with median ferruginous or yellow stains..... 6
- Ovipositor sheath about 0.45 as wide as hind femur and 3.5 as long as wide; median elevated quadrangular section of subtegular ridge with heavy, usually irregular ridges which sometimes enclose one or more depressed areas (figs. 44 and 45); central 0.65 of face elevated as a mound..... 7
6. Apical part of hind femur infusate or black; antennal socket not abnormally large, its diameter less than that of the scape; habitat: most of the Nearctic Region except west of the Continental Divide in the United States and southwestern Canada.....5a. **communis communis**
- Apical part of hind femur not or very slightly infusate; in specimens with the hind femur mostly black, the apex above is pale; antennal socket often abnormally large, its diameter usually equal to or greater than that of the scape; habitat: United States and southwestern Canada west of the Continental Divide.....5b. **communis foraminatus**
7. Second tergite closely and distinctly punctate, not conspicuously rugulose; clypeus with entire basal declivity blackish.....3. **mystax**
- Second tergite rather distantly or indistinctly punctate; usually conspicuously rugulose; clypeus with the basal declivity often more or less pale..... 8
8. Face and clypeus of male yellow; clypeus of the female with all or most of the basal declivity blackish; costula usually absent.....2. **alaskensis**
- Face of male black; clypeus of both sexes yellow with more or less of the basal declivity blackish; costula usually present..... 9
9. Hind coxa ferruginous or partly ferruginous; hind femur ferruginous; fore wing about 5.3 mm. long; subtegular ridge with an obtuse or weakly acute median dorsal tooth (fig. 44); face of male often with a median pair of yellow spots.....1. **rempeli**
- Hind coxa and femur black; fore wing about 7.0 mm. long; subtegular ridge with a strong acute median dorsal tooth (fig. 45); face of male entirely black.....4. **humeralis**

# 1. *Tryphon* (*Symboëthus*) *rempeli*, new species

Figure 44

*Subtegular ridge as in fig. 44, with an obtuse median dorsal tooth; face of male entirely or mostly black; costula usually present; second tergite rugulose.*

Fore wing about 5.3 mm. long; central 0.65 of face elevated as a mound; subtegular ridge with a poorly defined median dorsal tooth, below which is an elevated quadrangular area that is crossed by a few sharp coarse rugae (fig. 44); scutellum with lateral ridges only at its basal corners; propodeum polished and somewhat rugulose, the petiolar and posterior lateral areas strongly rugulose; sublateral section of apical carina joining lateral longitudinal carina far beyond the lateral section; costula usually strong; second tergite rugulose.

Black. Clypeus fulvous yellow with the basal 0.2 to 0.6 of its basal declivity blackish; palpi stramineous; mandible yellowish with the apical part ferruginous; face of male usually with a median pair of longitudinal oval yellow spots, of the female often with these spots indicated by indefinite ferruginous areas; scape and pedicel dark fulvous, blackish above; flagellum fuscous, dusky fulvous below, paler basally and especially pale in the female; tegula pale orange yellow; legs ferruginous with the hind coxa more or less blackish basally, especially

in the male; base of fore coxa of some males blackish; hind tibia basally and apically and tarsal segments, except basally, lightly infuscate; abdomen of female ferruginous, the first tergite varying from basally infuscate to black with its apical 0.15 ferruginous, and the sixth and seventh tergites and ovipositor sheath more or less infuscate; abdomen of male ferruginous, the first tergite black with its apical 0.15 ferruginous, the genitalia, the sixth, seventh, and sometimes also the fifth tergites partly or entirely blackish or infuscate; usually the second tergite of the male with a broad subbasal transverse infuscate or black band.

Our males from Mt. Rainier all have a pair of definite yellow marks on the face and the second and apical tergites each with a tendency to have a subbasal transverse fuscous band. The males from Saskatchewan have only ferruginous rudiments of the yellow facial spots, the second tergite uniformly ferruginous, and the apical tergites almost uniformly blackish.

*Type:* ♂, Mt. Rainier, Wash., taken in rank grasses and herbage at Longmire, elevation 2,700 ft., July 18, 1940, H. & M. Townes (Townes).

*Paratypes:* ♂, Bilby, Alta., Aug. 10, 1924, O. Bryant (Edmonton). ♀, Edmonton, Alta., Aug. 20, 1932, O. Peck (Townes). 4 ♂, ♀, Prince Albert National Park, Sask., J. G. Rempel (Townes), taken on the following dates: ♀, July 20, 1941; 2 ♂, July 25, 1940; and 2 ♂, Aug. 1, 1940. ♂, taken with the type (Townes). 2 ♂, ♀, Fish Creek at 2,900 ft., Mt. Rainier National Park, H. & M. Townes (Townes), taken on the following dates: ♂, July 28, 1940; ♀, July 29, 1940; and ♂, Aug. 14, 1940.

The species is known from Washington, Alberta, and Saskatchewan. The specimens taken by the authors are all from shrubbery and rank mixed grasses and herbage along streams, in two localities bordering between the Transitional and Canadian zones.

## 2. *Tryphon (Symboëthus) alaskensis*, Ashmead, new combination

*Polyblastus glacialis* Ashmead, 1902. Proc. Wash. Acad. Sci. 4: 213. Type: ♀, St. Paul Is., Alaska (Washington).

*Tryphon alaskensis* Ashmead, 1902. Proc. Wash. Acad. Sci. 4: 215. Type: ♀, St. Paul Is., Alaska (Washington).

*Face of male entirely yellow, subtegular ridge as in T. rempeli (fig. 44); costula usually absent.*

Fore wing about 5.6 mm. long; central 0.65 of face elevated as a mound; subtegular ridge with a poorly defined median dorsal tooth, below which is an elevated quadrangular area that is crossed by a few sharp coarse rugae; scutellum with lateral ridges only at its basal corners; propodeum somewhat dull and rugulose; sublateral section of apical propodeal carina joining lateral longitudinal carina far beyond the lateral section; costula usually lacking; second tergite closely rugulose and weakly indistinctly punctate.

Black. Face and clypeus of male yellow; face of female black; clypeus of female yellow with the basal declivity blackish or mostly blackish; palpi pale yellow; mandible yellow, ferruginous apically; under side of antenna fulvous; tegula stramineous to light brown; front and

middle coxae of male ferruginous to blackish, yellow beneath, of the female ferruginous to castaneous; hind coxa of male ferruginous with the base infusate, to entirely black, of the female castaneous to black; trochanters of male yellow, of female castaneous; femora ferruginous, the hind femur blackish apically; front and middle tibiae and tarsi of male yellow, of female pale ferruginous; hind tibia stramineous with the basal 0.15 and apical 0.3 infusate, from these bands gradually shading into the stramineous central portion of the tibia; segments of hind tarsus fuscous, stramineous basally; apical 0.5 to 0.12 of first tergite and all of the second, third, and fourth tergites ferruginous, or in some males these tergites more or less infusate and in some females the fourth tergite largely infusate; genitalia brown.

*Specimens:* ♂, Anchorage, Alaska, June 12, 1921, J. M. Aldrich (Washington). ♂, 2 ♀, Anchorage, Alaska, June 15, 1921, J. M. Aldrich (Washington). ♀, Naknek Lake, Savonoski, Alaska, July 13, 1919, J. S. Hine (Columbus). ♀, Naknek Lake, Savonoski, Alaska, July 19, A. J. Basinger (San Francisco). 5 ♂, 7 ♀, Naknek Lake, Savonoski, Alaska, July 25, 1919, A. J. Basinger and J. S. Hine (San Francisco, Columbus, and Townes). 3 ♂, ♀, St. Paul Is., Alaska, July 11, 1939, E. C. Johnson (San Francisco). ♂, St. Paul Is., Alaska, July-Aug., 1925, A. Christofferson (San Francisco). ♂, Banff, Alta., June 29, 1925, Owen Bryant (Washington). ♂, High Prairie, Alta., July 10, 1937, E. H. Strickland (Townes). ♀, Price Albert National Park, Sask., July 20, 1941, J. G. Rempel (Townes). ♂, Ashford, Wash., July 10, 1940, H. & M. Townes (Townes).

This species occurs from Alaska south to Saskatchewan and Washington. The specimen taken in Washington by the authors was found in mature *Pseudotsuga* forest (Transitional Zone) with considerable undergrowth, but the distributional records at hand indicate a more northern habitat as typical.

### 3. *Tryphon* (*Symboëthus*) *mystax*, new species

*Second tergite closely and conspicuously punctate, not conspicuously rugulose; basal declivity of clypeus black; scutellum without wing-like lateral margins; subtegular ridge not in the form of an upright lamina.*

Fore wing about 6.4 mm. long; central 0.65 of face elevated as a mound; subtegular ridge with an acute slightly projecting median dorsal tooth, below which is an elevated quadrangular area that is coarsely and sharply wrinkled; scutellum with lateral ridges only at its basal corners; propodeum somewhat dull and rugulose; sublateral section of apical propodeal carina joining lateral longitudinal carina far beyond the lateral section; costula weak or absent; second tergite with close distinct punctures, basally the punctures somewhat obscured by rugosity.

Black. Apical half of clypeus dark fulvous, the entire basal declivity black; mandible fulvous, dark ferruginous apically; labial palpus brown; maxillary palpus yellowish beyond the middle of the second segment, the rest dark brown; flagellum dusky fulvous, paler apically and below; tegula black; coxae black; basal trochanters black to dusky ferruginous, the apical trochanters somewhat paler; legs beyond trochanters ferruginous, the hind femur apically, the hind tibia basally and apically, and the segments of the hind tarsus except



basally all dusky; apical 0.12 to 0.4 of first tergite, all of second and third tergites, and basal 0.3 to all of fourth tergite ferruginous.

A male from Fairbanks, Alaska, has an indistinct median transverse fuscous band on the second and third tergites and a male from Bayfield, Colo., has the fore femur infusate basally, the middle femur entirely infusate, and the hind femur black.

*Type:* ♀, Waskesiu, Sask., June 16, 1938, J. G. Rempel (Townes).

*Paratypes:* ♀, Anchorage, Alaska, June 15, 1921, J. M. Aldrich (Washington). ♂, Fairbanks, Alaska, June 30, 1921, J. M. Aldrich (Washington). 2 ♂, ♀, Edmonton, Alta., July 6, 1940, July 9, 1929, and July 14, 1935, E. H. Strickland (Edmonton). ♀, Ground Hog Basin in the Big Bend country of the Selkirk Mts., B. C., Aug. 4, 1905, J. C. Bradley (Ithaca). ♂, Granite Peaks Camp at 9,000 ft., Bayfield, Colo., July 18 to 31, 1928, J. Bequaert (Cambridge). ♂ Rocky Mt. National Park at 9,400 ft., June 16, 1948, H., M., G., D., & J. Townes (Townes). ♀, Rocky Mt. National Park at 9,400 ft., Aug. 9, 1949, H., M., D., & J. Townes (Townes). ♂, Oquossoc, Me., July 3, 1922 (Cambridge). ♂, Bretton Woods, N. H., June 30, 1909, E. P. VanDuzee (San Francisco). ♂, Normandale, Ont., June 5, 1931, G. S. Walley (Ottawa). ♀, Knowlton, Que., June 25, 1929, L. J. Milne (Ottawa). ♂, Megantic, Que., June 16, 1923, C. H. Curran (Ottawa). 10 ♂, ♀, Mt. Lyall at 1,500 ft., Que., W. J. Brown (Ottawa), taken in 1933 on the following dates: 3 ♂, July 25; 2 ♂, ♀, July 26; ♂, July 27; 2 ♂, July 31; ♂, Aug. 2; and ♂, Aug. 7. 2 ♂, 4 ♀, Waskesiu, Sask., J. G. Rempel (Townes), taken in 1938 on the following dates: ♀, June 14; 2 ♂, 2 ♀, June 15; and ♀, June 16. ♀, Ashford, Wash., July 20, 1940, H. & M. Townes (Townes). ♂, Mt. Rainier, Wash., at 4,700 ft., July 11, 1940, H. & M. Townes (Townes).

This species occurs across the continent in the Canadian Zone. The specimen from Ashford, Wash., was taken in the Transitional Zone, but this habitat appears unusual.

#### 4. *Tryphon (Symboëthus) humeralis*, new species

Figure 45

*Subtegular ridge with a strong acute median dorsal tooth; hind femur black.*

Fore wing about 7.0 mm. long; central 0.65 of face elevated as a mound; subtegular ridge with an acute strongly projecting median dorsal tooth, below which is an elevated quadrangular area with a few strong ridges usually enclosing a strong depression (fig. 45); scutellum with lateral ridges only at its basal corners; propodeum somewhat dull and rugulose; sublateral section of apical propodeal carina joining the lateral longitudinal carina far beyond the lateral section; costula strong; second tergite rugulose and with indistinct punctures.

Black. Clypeus yellow, fulvous apically; mandible yellow, shading to dark ferruginous at the tip; palpi yellow, the basal part of their basal segments more or less brown; flagellum pale beneath, extensively so towards the apex; tegula black; coxae black, their apices usually pale; basal trochanters brown to blackish, their apices pale and the hind basal trochanter darkest; apical trochanters brown to ferruginous; front and middle legs beyond trochanters ferruginous, their tibiae paler and

their femora sometimes infusate above; hind femur black; hind tibia stramineous, its basal  $0.12\pm$  and apical  $0.45\pm$  infusate, the fuscous and stramineous areas not sharply delimited; segments of hind tarsus fulvous, infusate apically; apical 0.2 to 0.5 of first tergite, all of second to fourth tergites, and sometimes the basal 0.4 of the fifth tergite in the male, or in the female as much as all of the fifth and basal 0.4 of the sixth tergite ferruginous.

The female from Mackinaw Co., Mich., has the clypeus blackish with the median transverse ridge dark ferruginous. All other specimens have the clypeus entirely pale except often for its basal margin.

*Type*: ♂, collected in a rank growth of *Equisetum arvense*, grasses, sedges, and low willows along the marshy edges of a small bottomland stream at the CCC camp at Moosic, Pa., May 16, 1945, H. Townes (Townes).

*Paratypes*: 3 ♀, Rocky Mt. National Park at 9,400 ft., Aug. 8 and 9, 1948, H., M., D., & J. Townes (Townes). ♂, Oquossoc, Me., July 5, 1942 (Cambridge). ♀, Mackinaw Co., Mich., July 5, 1937, R. R. Dreisbach (Townes). ♂, Jaffrey, N. H., June 16 (Cambridge). ♂, Ithaca, N. Y., June 6, 1937, P. P. Babiý (Townes). ♀, Patterson, N. Y., June 17, 1937, H. Dietrich (Ithaca). ♂, Saranac Lake, N. Y., June 23, 1946, R. T. Mitchell (Mitchell). ♂, collected with the type (Townes). ♂, collected at the type locality, May 4, 1945, H. Townes (Townes). ♂, near Cookshire, Que., June 23, 1938, H. & M. Townes (Townes). ♀, Burlington, Vt., June 22, 1906 (Cambridge).

##### 5. *Tryphon* (*Symboëthus*) *communis* Cresson, new combination

Figures 35 and 47

*Ovipositor sheath about 0.7 as wide as the hind femur.*

Fore wing typically about 8.0 mm. long, but size often much smaller; face unusually broad, its central 0.75 elevated as a flattened mound; subtegular ridge with a strong median dorsal tooth, below which is an elevated quadrangular area that is obliquely concave and traversed by some rather fine oblique ridges (fig. 47); scutellum with lateral ridges only at its basal corners; propodeum polished and more or less rugulose; sublateral section of apical propodeal carina joining lateral longitudinal carina far beyond lateral section; costula usually strong; second tergite closely and rather strongly rugulose, with some indistinct punctures; ovipositor sheath about 0.7 as wide as the hind femur and 2.0 as long as wide (fig. 35); ovipositor strongly down-curved. (In all other species of the subgenus the ovipositor sheath is about 4.5 as wide as the hind femur and about 3.5 as long as wide, and the ovipositor is straight or weakly downcurved.)

*Tryphon communis* is represented by the two subspecies described below, one of which has a well marked color variety. For descriptions of coloration see under these.

*Specimens*: For detailed data, see under the two subspecies.

This species occurs in damp grassy places throughout the Transitional and Canadian Zones, and probably also throughout the Hudsonian Zone of North America from Nova Scotia to Maryland and west to

Alaska, California, and New Mexico. There seems to be a single generation per year, the adults being on the wing in Transitional localities from the last of May through June, with smaller numbers present until early in August. In more northern localities it is common in July. Early and late collecting dates of interest are April 18 at Tuolumne, Calif.; May 5 at Columbia, Mo.; May 16 at South Hadley, Mass.; May 18 at Rock Island, Ill.; May 19 at Columbus, Ohio and at Ithaca, N. Y.; May 20 at Spring Brook, Pa.; May 21 at Houston Co., Minn.; May 22 at Agassiz, B. C.; May 31 at Stittsville, Ont.; August 8 at Herkimer, N. Y.; August 9 at Chester, Mass.; August 12 at Truro, N. S.; August 15 at Rutland, Vt.; and August 19 at Ashford, Wash., at Ile de Montreal, Que., and at Ft. Kent, Me. Males predominate earlier in the season and females later, but males are not rare in July and one was caught August 9, at Chester, Mass. In the Hudsonian Zone of Mt. Rainier, Wash. (at 5,300 ft.), the authors found males as late as August 16. The species appears on the wing later than most others of its genus.

5a. *Tryphon* (*Symboëthus*) *communis communis* Cresson,  
new combination

*Tryphon communis* Cresson, 1868. Trans. Amer. Ent. Soc. 2: 103. Type ♂, Pa. (Philadelphia).

*Tryphon clypeatus* (as *T. clypealis* on p. 309) Provancher, 1875. Nat. Canad. 7: 309, 311. Type: ♂, Que. (Quebec).

*Tryphon pediculatus* Provancher, 1886. Addit. Faune Canada Hymén. p. 102. Type: ♂, Bécancour, Que. (Quebec).

*Tryphon communis* var. *alripes* Davis, 1898. Trans. Amer. Ent. Soc. 24: 282. New synonymy. Type: ♀, north Ill. (Philadelphia).

*Grypocentrus rufiterminalis* Hall, 1919. Psyche. 26: 157. Type: ♀, Petersham, Mass. (Cambridge).

Differs from the other subspecies (*foraminatus*) in having the antennal socket of normal size, its diameter distinctly smaller than that of the scape, and in having the hind femur blackish or infusate apically above or sometimes entirely blackish.

The color is unusually variable. Typically it is as follows: Black. Clypeus, mandible, and palpi yellow, the mandible ferruginous apically and the clypeus with its basal 0.1 to 0.2 black; under side of flagellum dusky fulvous, more extensively so towards its apex; tegula yellow or ferruginous to black; legs ferruginous, the hind femur apically above blackish, the hind tibia with about its basal 0.15 and apical 0.45 more or less infusate, and the segments of the hind tarsus more or less infusate toward their apices; central part of hind tibia pale fulvous and shading gradually into the infusate basal and apical portions; basal 0.5± of first tergite and often the apical part of the abdomen black, the rest of the abdomen ferruginous.

Common variations include forms with as much as the basal 0.4 of the clypeus black or sometimes the clypeus dark ferruginous brown or blackish with a central transverse paler band. There are varying amounts of infuscation on the legs, commonly including a black hind coxa and femur and sometimes black fore and middle coxae, more or less infuscation on the trochanters, basal part of the fore and middle femora, and of the hind tibia and tarsus. The amount of black on the first

tergite and on the apical part of the abdomen varies considerably. Sometimes the hind tibia and tarsus are almost uniformly ferruginous. Males frequently have the entire abdomen black or blackish. These in the past have been designated the variety *clypeatus*, and because of this and the infrequency of intergrades, distribution records for this color form are discussed separately below. Specimens from Alaska are rather uniformly small, dark, and with the abdomen beyond the fourth or fifth tergites blackish, but are not given a separate name in this paper.

*Specimens* (excluding males with the abdomen black): Many males and females from ALASKA (Anchorage, Fairbanks, Healy, and Skagway); ALBERTA (Banff); COLORADO (Rocky Mt. National Park at 9,400 ft.); CONNECTICUT (Hartford); DISTRICT OF COLUMBIA (Washington); ILLINOIS (Algonquin, Oregon, Rock Island, Savoy, and Sherman); MAINE (Ft. Kent, Lincoln Co., Portland, Salisbury Cove, and Southwest Harbor); MANITOBA (Transcona); MASSACHUSETTS (Auburndale, Chester, Fitchburg, Holliston, North Adams, Princeton, Southbridge, and South Hadley); MICHIGAN (Arenac Co., Clare Co., East Lansing, Iosco Co., Lapeer Co., Mecosta Co., Midland Co., and Missaukee Co.); MINNESOTA (Chisago Co., Grand Rapids, Houston Co., Itasca Park, and Rice Co.); MISSOURI (Clayton and Columbia); NEW BRUNSWICK ("Barber D." and St. Andrews); NEW HAMPSHIRE (Bretton Woods, Hanover, Jaffrey, Mt. Washington, and Pinkham Notch); NEW YORK (Alleghany State Park, Axton in the Adirondack Mountains, Bemus Point, Breesport, Heart Lake in Essex Co., Herkimer, Ithaca, Junius, Labrador Hollow in Onondaga Co., McLean, Milford Center, Mix Creek Valley in Cattaraugus Co., Mt. Marcy, Oswego, Pulaski, Raquette Lake, Rome, Salisbury Center, Saranac Lake, Spencer Lake, and Syracuse); NORTH DAKOTA (Forman); NOVA SCOTIA (Truro and Kings Co.); OHIO (Akron and Marion Co.); ONTARIO (Alexander Bay, Bell's Corners, Bobcaygeon, Ft. Erie, Hastings Co., Kearney, Leamington, Merivale, Moosonee, Orillia, Ottawa, Stittsville, Smoky Falls in the Mattagami River, Strathroy, and Waubamie); PENNSYLVANIA (Camphill, Kingsley, Spring Brook, Wilawana, and Youngwood); QUEBEC (Aylmer, Beaulieu, Bolton Glen, Brome, Cascapedia, near Cookshire, Ft. Coulonge, Gracefield, Granby, Hemmingford, Hull, Joliette, Knowlton, Lac Mercier, Laval Co., Meach Lake, Mer Bleue, Montreal, Mt. Lyall at 1,500 ft., Stoneham, and Valley Junction); SASKATCHEWAN (Prince Albert National Park and Waskesiu); and VERMONT (Burlington, Jacksonville, Lake Willoughby, Plainfield, Rutland, and St. Albans). Specimens from Alberta (Banff, Bilby, and Lethbridge) are intermediate to the subspecies *foraminatus*. Their antennal sockets are usually somewhat enlarged but the hind femur may have the apical dorsal blackish area distinct or practically absent. In addition there is a male from Jemez Spring, N. Mex., which probably belongs to the present subspecies. Its hind femur is entirely black.

This subspecies occurs east of the Rocky Mountains. Alaskan material is placed here also.

There is a distinctive color variety of this subspecies differing in having the abdomen entirely or almost entirely black or blackish. It is known only in the male sex. We have seen specimens of it from:

COLORADO (Ft. Collins); ILLINOIS (Savoy and Urbana); IOWA (Ames); MAINE (Mt. Desert); MICHIGAN (Agricultural College, Iosco Co., and Midland Co.); MINNESOTA (Fillmore Co., Houston Co., Itasca Park, Loman, and Traverse Co.); NEW BRUNSWICK ("Barber D."); NEW HAMPSHIRE (Glen House, Jaffrey, and North Adams); NEW YORK (Center Lake, Downsville, Ithaca, McLean, Mix Creek Valley in Cattaraugus Co., Oswego, Rock City in Cattaraugus Co., Saranac Lake, Slide Mt., Spencer Lake, and Syracuse); NOVA SCOTIA (Truro); ONTARIO (Hastings Co., Leamington, Ottawa, and Toronto); PENNSYLVANIA (Spring Book and Wilawana); and QUEBEC (Brome, Gracefield, Hull, Joliette, Knowlton, Lac Ste. Marie, Montreal, Quebec, and Valley Junction).

This variety seems to occur throughout the range of the subspecies. It may occur in as much as 50% of the males of a population, as was found about May 20, 1945, at Spring Brook, Pa., or may be absent where typical males are common. There seems a tendency for it to be more common among earlier season males than among later ones. A corresponding dark male variety is very infrequent in the subspecies *foraminatus*.

5b. *Tryphon (Symboëthus) communis foraminatus*,  
new subspecies

Differs from the typical *communis* in having the antennal foramen more or less enlarged, especially in the male. The foramen is usually larger than the diameter of the scape and contains an unusually conspicuous yellow connecting area. The apex of the hind femur is not or only slightly infusate and the general coloration of the legs and abdomen is usually more uniformly bright ferruginous than in the typical subspecies.

*Type*: ♀, Ashford, Wash., July 10, 1940, H. & M. Townes (Townes).

*Paratypes*: Many males and females from BRITISH COLUMBIA (Carbonate on the Columbia River at 2,600 ft., Corfield, Kaslo, and Vancouver); CALIFORNIA (Angora at Lake Tahoe, Cisco, Cobb Mt. in Lake Co., Donner Pass, "Gr. Alpine Cr." at Tahoe, Herkey Creek and Idyllwild in the San Jacinto Mts., Tejon Canyon in Kern Co., Tuolumne and Yosemite Park at 8,700 ft. and 10,500 ft.); COLORADO (Forresters); IDAHO (Troy); MONTANA (Belton and Drummond); OREGON (Cannon Beach, Corvallis, Fish Lake at 7,000 ft. in the Steens Mountains, Haines, Seneca, and Strawberry Camp at 5,700 ft. in Grant Co.); WASHINGTON (Ashford, Elbe, Olympia, and Mt. Rainier at the elevations of 2,700 ft., 2,900 ft., 4,200 ft., 5,000 ft., and 5,300 ft.); and WYOMING (Big Horn Mountains near Buffalo at 6,000 ft.). These are in the collections of Townes, Washington, Corvallis, San Francisco, Ithaca, Lawrence, Ottawa, Berkeley, Bohart, and Philadelphia.

In addition to the above, there is a series of 31 ♂, 22 ♀ from Fish Camp, Calif. (Townes Collection) which may represent a third subspecies. The specimens are very close to *communis foraminatus* but the ovipositor sheath is shorter and broader, and ovipositor shorter and more strongly curved, and there are some additional minor differences.

This subspecies is limited to the United States and Canada west of the Continental Divide. It shows its subspecific characters most strongly in Washington State in and west of the Cascade Range. A large series from Alberta (Banff, Bilby, and Lethbridge) is intermediate to typical *communis*. Some of the specimens almost lack the femoral dark mark. Others have it distinct. The antennal foramen is distinctly enlarged in most of the specimens. The ecology and seasonal distribution appear to be the same as in the typical subspecies but perhaps with most of the adults on the wing a little later in the season. The specimens before us were taken largely in July and August.

#### 6. *Tryphon* (*Symboëthus*) *illotus*, new species

Figure 46

*Scutellum bordered by strong lateral ridges almost to its apex; clypeus entirely black.*

*Type male:* Fore wing 6.8 mm. long; central 0.6 of face elevated as a somewhat irregular mound; subtegular ridge rather sharp, arched, joined medially from above by a short strong carina, anteriorly below sloping off to the mesopleurum, its posterior half subtended by a deep cleft (fig. 46); scutellum with strong lateral ridges almost to its apex, between which it is polished, weakly convex and sparsely punctate; propodeum polished and weakly rugulose; sublateral section of apical carina joining lateral longitudinal carina far beyond the lateral section; costula strong; second tergite polished and finely punctate.

Black. Apical half of clypeus piceous; mandible blackish, the apical half dusky ferruginous (the mandible of the type may be discolored and may have been yellowish or ferruginous in life); palpi light brown, the basal segment of each piceous; tegula black; middle and hind coxae black; fore coxa and first trochanters piceous; legs beyond first trochanters ferruginous, with the apex of the hind femur, hind tibia, and of the hind tarsal segments somewhat infusate; median apical part of first tergite and all of the abdomen beyond its first segment ferruginous.

*Type:* ♂, Pullman, Wash., May 28, 1917, H. C. Donohoe (St. Paul).

#### 7. *Tryphon* (*Symboëthus*) *viator*, new species

Figure 48

*Subtegular ridge projecting upwards as a lamina; costula present.*

Fore wing about 6.5 mm. long; entire face evenly convex across the middle; subtegular ridge projecting upwards as a lamina with its margin sharp and rather evenly convex, without a median dorsal tooth (fig. 48); scutellum with lateral ridges only at its basal corners; propodeum polished and rugulose, the lateral and sublateral sections of its apical carina interstitial at the lateral longitudinal carina; costula present; second tergite with close, distinct punctures.

Black. Clypeus, mandible, and palpi yellow or fulvous, the apical part of the mandible and sometimes the apical 0.4± of the clypeus ferruginous; antenna fulvous, more or less infusate above and medially; tegula yellow; legs ferruginous with the tibiae and tarsi pale ferruginous, the apex of the hind femur blackish above and the hind tibia with its

apical 0.3 infusate and sometimes the basal 0.12 = somewhat darkened, the infusate ends fading gradually into the pale central portion; abdomen ferruginous, the basal 0.3 to 0.7 of the first tergite black or blackish and frequently the apical tergites black or blackish to as far basad as the fourth tergite.

*Type*: ♀, collected among grass and *Solidago* along a small stream at the edge of a woodlot eight miles southeast of the center of Akron, Ohio, May 18, 1941, H. Townes (Townes).

*Paratypes*: Many males and females from ALBERTA (Radnor); COLORADO (Boulder); CONNECTICUT (Darien); ILLINOIS (Champaign Co., Decatur, Fountain Bluff, Oakwood, Pulaski, and Watseka); IOWA (Jefferson Co. and Washington Co.); KANSAS (Baldwin); MAINE (Southwest Harbor); MANITOBA (Victoria Beach); MASSACHUSETTS (Rutland); MICHIGAN (Agricultural College and Detroit); MINNESOTA (Crookston, Floodwood, Itasca Park, Luverne, Marshall Co., and Mille Lacs Lake near Vineland); MISSOURI (Columbia and New Hartford); NEW HAMPSHIRE (Glen House and Hampton); NEW YORK (Armonk, Dix Hills on Long Island, Ithaca, McLean, Mix Creek Valley and Rock City in Cattaraugus Co., Orient, Waterville, and West Nyack); OHIO (Akron, Columbus, London, and Sandusky); ONTARIO (Blackburn, Leamington, Mer Bleue, and Normandale); PENNSYLVANIA (Spring Brook); QUEBEC (Aylmer, Bolton Glen, Brome, Bursidge, Gracefield, and Stoneham); RHODE ISLAND (Westerly); and SASKATCHEWAN (Dafoe). Paratypes are in the collections of Townes, Ottawa, Washington, Ithaca, Urbana, Cambridge, Lawrence, St. Paul, and Edmonton.

The species occurs in damp grassy places throughout the Transitional Zone and in the warmer part of the Canadian Zones from the Atlantic coast west to Alberta and Colorado. There is a single generation a year. In most localities, the adults begin to appear in numbers between May 15 and May 20, are common until about June 15, and scarce afterwards. We have records of three captures in July. Early and late records of interest are May 3 at Columbia, Mo.; May 13 at McLean, N. Y.; May 16 at Spring Brook, Pa.; May 18 at Akron, Ohio; May 19 at Decatur, Ill.; May 22 at Hampton, N. H.; May 25 at Brome, Que.; June 30 at Victoria Beach, Man.; July 2 at Floodwood, Minn.; July 7 at Dafoe, Sask.; and July 18 at Orient, N. Y. Males are somewhat more abundant in the early part of the season and females later.

8. *Tryphon* (*Symboëthus*) *americanus* Cresson,  
new combination

*Tryphon americanus* Cresson, 1864. Proc. Ent. Soc. Phila. 3: 276. Type: ♂, Del. (Philadelphia).

*Tryphon affinis* Cresson, 1864. Proc. Ent. Soc. Phila. 3: 277. Type: ♀, Penn. (type lost).

*Propodeum with four high sharp longitudinal carinae and no cross carinae.*

Fore wing about 7.0 mm. long; entire face evenly convex across the middle; subtegular ridge projecting upwards as a lamina with its margin sharp and rather evenly convex, without a median dorsal tooth (as in *T. viator*, fig. 48); scutellum with lateral ridges only at its basal corners;

propodeum with four very high longitudinal carinae extending from its base to its apex, between which the propodeum is concave, polished and impunctate; pleural areas of propodeum normal, somewhat polished and rugulose; costula and petiolar area not present; second tergite closely rugulose with indistinct punctation, to punctate with indistinct rugulosity.

*Male:* Black. Face, clypeus, palpi, and mandible yellow, the mandible ferruginous apically; scape and pedicel yellow below, dusky above; flagellum fulvous apically and basally, the basal few segments below usually yellowish; tegula yellow; fore and middle legs yellow, their femora tinged with ferruginous above; hind coxa black with the apex yellowish, to ferruginous with the base black and the apex yellowish; hind trochanters yellow; hind femur with the extreme base yellow, the rest black or ferruginous with an apical dorsal black mark (Intergrades between the black and ferruginous types of hind femur are unusual); hind tibia stramineous with its basal  $0.15\pm$  and apical  $0.4\pm$  fuscous, the fuscous bands not sharply set off from the median paler portion; segments of hind tarsus dusky, stramineous basally.

*Female:* Colored like the male except that the face is black or black with a pair of ill-defined median yellow or ferruginous spots, the clypeus often blackish on its basal  $0.2\pm$ , the front and middle legs and hind trochanters ferruginous, the hind coxa ferruginous with its base more or less infuscate, the hind femur ferruginous with an apical dorsal black mark or rarely black with its extreme base pale ferruginous, and the hind tibia somewhat more extensively marked with fuscous. Rarely the face is almost entirely yellow.

*Specimens:* Many males and females from ILLINOIS (Algonquin, Aurora, Chicago, Decatur, Freeport, Kappa, Muncie, Oakwood, and Urbana); INDIANA (Huntington and Turkey Run); IOWA (Ames, Des Moines Co., Henry Co., Jefferson Co., and Mt. Pleasant); KANSAS (Baldwin); MASSACHUSETTS (Great Barrington and South Hadley); MICHIGAN (Eaton Co., Midland Co., and Nottawa); MINNESOTA (Goodhue Co., Houston Co., Mille Lacs Co., Olmsted Co., and St. Paul); NEW JERSEY (Ramsey); NEW YORK (Bemus Point, Ithaca, Oneonta, Rock City in Cattaraugus Co., and Van Courtland Park); OHIO (Akron, Bedford, Columbus, Danville, Licking Co., McGuffey, Wayne Co., and Wooster); ONTARIO (Bell's Corners, Blackburn, Leamington, MacDiarmid at Lake Nipigon, Ottawa, Thunder Bay Beach, Toronto, and Waubamie); PENNSYLVANIA (Highspire, Hummelstown, North Cumberland, and Perdit); QUEBEC (Aylmer, Gracefield, Hull, and Kazubazua); and RHODE ISLAND (Westerly).

This species occurs in moist rank grass in the Transitional Zone of eastern North America, from Quebec and Ontario in the north, south to Pennsylvania and west to Minnesota and eastern Kansas. There is one generation a year, the adults being on the wing from about May 15 to about June 15. The earliest and latest collecting dates known to us are May 9 in Douglas Co., Kansas, and July 20 at Van Courtland Park, N. Y. Most of the males appear and disappear about a week earlier than most of the females. Specimens with the hind femur mostly black and those with it mostly ferruginous occur together, the former variety being somewhat less common in males and scarce in females.



9. *Tryphon* (*Symboëthus*) *seminiger* Cresson,  
new combination

Figure 42

*Tryphon seminiger* Cresson, 1864. Proc. Ent. Soc. Phila. 3: 278. Type: ♀, Ill. (Philadelphia).

*Meloplus terminalis* Ashmead, 1890. Proc. U. S. Nat. Mus. 12: 438. Type: ♂, Mo. (Washington).

*Scutellum with strong wing-like lateral carinae to its apex.*

Fore wing about 7.0 mm. long; face irregularly convex, its central 0.3 rather abruptly elevated and somewhat flattened medially; sub-tetragular ridge with a strong median dorsal tooth, below which is an elevated quadrangular area that is strongly obliquely concave; scutellum with strong wing-like lateral carinae to its apex and often a weak ridge across its apex, between the ridges convex and with a weak median longitudinal ridge posteriorly; propodeum subpolished and more or less rugose, the lateral and sublateral sections of the apical carina nearly or quite interstitial at the lateral longitudinal carina; costula present; second tergite mat, with fine close punctures; seventh tergite of female very narrow medially so that the end of the abdomen appears excavated above; apical part of penis slightly enlarged, with a thin ventral lamina extending almost to its apex. (In all of the other species of the subgenus the seventh tergite of the female is not unusually narrow dorsally and the apical part of the penis is decurved and bulbously swollen.)

Black. Clypeus, mandible, and palpi yellowish with the apical part of the mandible ferruginous and the clypeus often margined basally with black; scape fulvous below; flagellum more or less fulvous apically and below; tegula yellow to ferruginous or black, usually yellow or ferruginous with the mesal 0.4= blackish; coxae black with more or less of their apices or sometimes all but their bases ferruginous; legs beyond coxae ferruginous except that in the hind legs the femur is blackish apically above, the tibia is dusky on its apical 0.25= and the tarsal segments are more or less infusate apically; abdomen ferruginous, the first tergites with its basal 0.4 to 0.8 black. Some males and a few females, especially those emerging early in the season or from more northern localities, are more extensively marked with black. In these the hind leg beyond the coxa is more or less completely infusate or black, the apical part of the abdomen is black, and sometimes the abdominal tergites are almost entirely black except that the apex of the first and more or less of the second, third, and fourth tergites are ferruginous or blackish tinged with ferruginous.

*Specimens:* Many males and females from ALASKA (Anchorage, and Fairbanks); ALBERTA (Athabasca and Fawcett); BRITISH COLUMBIA (Agassiz, Keremeos, Mission, Oliver, and Vancouver Island); CALIFORNIA (Berkeley, Big Flat on Coffee Creek in Trinity Co., Carmel, Carrville in Trinity Co., Donner Pass, Dunsmuir, Jamesburg in Monterey Co., Pine Valley in San Diego Co., San Mateo Co., and Santa Cruz); COLORADO (Green Mt. Falls, Lyons, Nederland, and Yale Lake at Buena Vista); IDAHO (Warren); ILLINOIS (Algonquin, Anna, Chicago, Decatur, Dongola, Dixon, McHenry, Mahomet, Muncie, Oakwood, Ogden, Savanna, Savoy, Seymour, Urbana, and White Heath); IOWA (Iowa City, Jefferson Co., and Mt. Pleasant); MARYLAND

(Cabin John, Plummers Island, and Takoma Park); MASSACHUSETTS (Blue Hills and Holliston); MICHIGAN (Agricultural College, Ann Arbor, Arenac Co., Crawford Co., East Lansing, Isabella Co., Lapeer Co., and Midland); MINNESOTA (Crookston, Cushing, Houston Co., Itasca Park, Kittson Co., Marshall Co., Sedah, and Traverse Co.); NEW JERSEY (Branchville, Clementon, Englewood, Moorestown, and Ramsey); NEW MEXICO (Jemez Springs); NEW YORK (Armonk, Axton in the Adirondack Mts., Breesport, Buffalo, Centereach and Dix Hills on Long Island, Dryden Lake in Tompkins Co., Geneva, Ithaca, Malloryville in Tompkins Co., Lancaster, Lockport, McLean, Oswego, Pelham Bay Park, Poughkeepsie, Rock City in Cattaraugus Co., Slaterville, Spencer Lake, Syracuse, and West Nyak); NORTHWEST TERRITORIES (Ft. Norman on the McKenzie River); NOVA SCOTIA (Halifax and Truro); OHIO (Cedar Point near Sandusky, Columbus, Danville, Dayton, Hinckley in Medina Co., Marion Co., McGuffey, Ottawa Co., Painesville, Summit Co., Troy, and Wood Co.); ONTARIO (Carp, Coniston, Eldorado in Hastings Co., Fisher Glen, Leamington, Mer Bleue, Ottawa, Parry Sound, Simcoe, Smoky Falls in the Mattagami River, Sudbury, Swansea near Toronto, Thunder Bay Beach, and Walsh); OREGON (Bloomington, Cornelius, Corvallis, Hood River, Mt. Hood at 4,000 ft., Portland, Summit Prairie in Grant Co., Union at 2,788 ft., and Woods Creek Road); PENNSYLVANIA (Harrisburg, Morrisville, Philadelphia, Spring Brook, Spring Mill, Tioga Co., Wilawana, and Willow Grove); QUEBEC (Brome, Gracefield, Hemmingford, Hull, Joliette, Knowlton, Lanoraie and Montreal); RHODE ISLAND (Bristol and Westerly); SASKATCHEWAN (Nipawin, Prince Albert National Park, Saskatoon, and Waskesiu); SOUTH DAKOTA (Custer); UTAH (Utah Lake); VERMONT (Bennington); WASHINGTON (Ashford, Elbe, Lake Quinault, Metaline Falls, Mt. Rainier at 4,700 and at 6,000 ft., Seattle, and Wenatchee Mts.); and WISCONSIN (Milwaukee).

This species occurs in damp grassy places throughout the Transitional, Canadian, and Hudsonian zones from Nova Scotia and Maryland west to Alaska, Berkeley in California, and northern New Mexico. Probably it occurs in the Alpine Zone also. There seems to be a single generation a year, the adults being on the wing in Transitional localities from about May 20 to July 10, with a few stragglers to early September. These very late specimens possibly represent a partial second generation. In more northern localities the species is common in July. Early and late collecting records of interest are April 7 at Berkeley, Calif.; May 5 at Corvallis, Ore.; May 7 at Agassiz, B. C.; May 10 at Mt. Pleasant, Ia.; May 14 at Spring Brook, Pa.; May 16 at Morrisville, Pa.; May 17 at Ithaca, N. Y.; May 18 on Woods Creek Road, Oreg.; May 19 at Decatur, Ill., and at Columbus, Ohio; May 29 in Houston Co., Minn.; July 25 at Elbe, Wash.; July 29 at Waskesiu, Sask.; Aug. 3 at Jemez Springs, N. Mex.; Aug. 6 at Ft. Norman, McKenzie River, N. W. Terr.; Aug. 12 at Truro, N. S.; Sept. 1 at Eldorado in Hastings Co., Ont.; and Sept. 12 at Willow Grove, Pa. Males are more common than females for the first week of the adult season and about equally common for the rest of the season.

## TWO NEW SPECIES OF CADDIS FLIES (TRICHOPTERA) FROM WASHINGTON STATE

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This report describes two new species of caddis flies which have been encountered in a taxonomic study of the Trichoptera of the state of Washington.

The author is indebted to Dr. H. H. Ross for checking the specimens herein described.

### Family Rhyacophilidae

#### *Rhyacophila latitergum*, new species

This species is closely related to *rotunda* Banks and *norcuta* Ross. It can readily be distinguished from *rotunda* by the forewing venation in which cell  $R_2$  does not extend basad of cell  $R_4$ ; it can be distinguished from *norcuta* and *rotunda* by the tenth tergite, which is greater in width than length, in the male.

*Male*.—Length 11 mm. Head and thorax dark brown, almost black; antennae, warts of head and prothorax, and tegulae brown, the antennae annulated with light brown at joints; palpi pale. Front and middle legs brown except for a yellowish-brown band on each tibia, occupying the region distad of the subapical spurs; hind leg conspicuously pale except for proximal third of femur which is brown and the tip of the tarsus which gradually becomes darker. Wings uniformly brown, without markings except the stigmatic area is somewhat lighter; forewing with cells  $R_2$  and  $R_4$  extending approximately equidistant basad.

Genitalia as in Fig. 1. Ninth abdominal segment angulate from lateral view, being greatly narrowed ventrally to receive base of clasper. Tenth tergite rather large with a superior structure trilobed from dorsal aspect and slightly wider than long; inferior structure of tenth tergite complex, see Fig. 1B. Basal segment of clasper broad at base, apicoventral corner produced ventrad, and a short longitudinal crease on ventral margin at base of apicoventral projection; apical segment short and wide with dorsal angle reduced and angular, ventral angle produced and rounded, posterior margin between angles slightly incised. Aedeagus with a superior, sclerotized, trough-like flap with apex produced into a narrow, pointed tube; laterally and below there is a pair of membranous, extensile structures, each terminating in a sclerotized blade bearing long setae from its mesal surface.

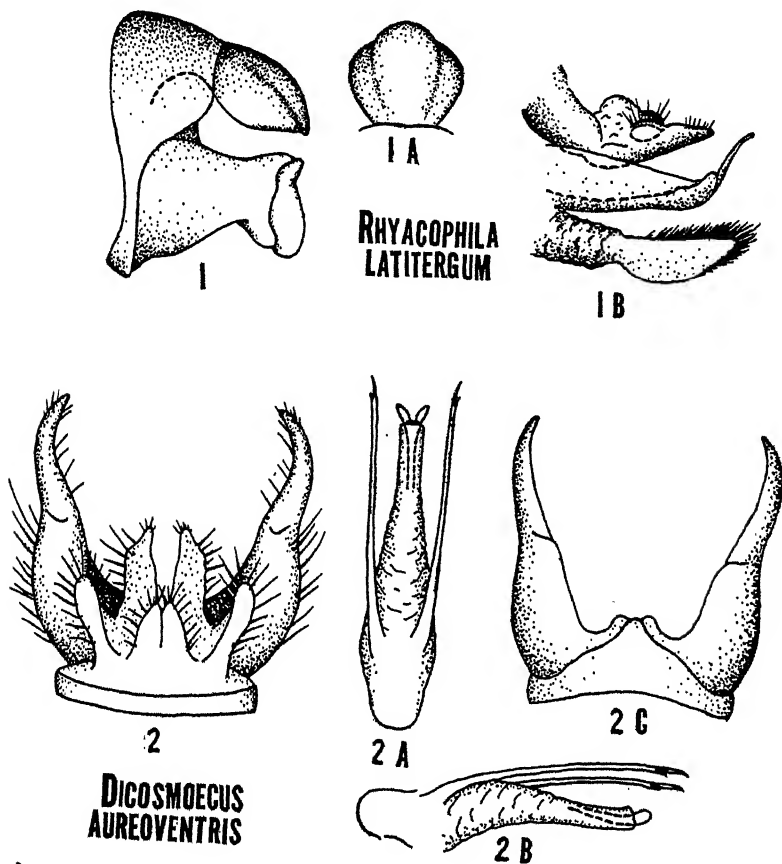
*Female*.—Unknown.

*Holotype*.—Male, Tomyhoy Lake, Whatcom County, Washington, August 4, 1946 (J. J. Davis); in collection of Illinois Natural History Survey, Urbana, Illinois.

## Family Limnephilidae

*Dicosmoecus aureoventris*, new species

This is an interesting and rather unique species which may be an intermediate between the *unicolor* and *atripes* groups. The male can be readily distinguished from both of these groups by the combination of long narrow claspers and short cerci. It differs from all species of the genus in the long lateral arms of the aedeagus.



*Rhyacophila latitergum*, male genitalia. Fig. 1, lateral aspect; 1A, dorsal aspect of tenth tergite; 1B, lateral aspect of aedeagus and inferior structure of tenth tergite.

*Dicosmoecus aureoventris*, male genitalia. Fig. 2, dorsal aspect; 2A, dorsal aspect of aedeagus; 2B, lateral aspect of aedeagus; 2C, ventral aspect of claspers.

*Male*.—Length 20.5 mm. Dorsum of head and thorax black, warts clothed with black hair; face and mouth parts golden colored; antennae black, serrate on ventral surface; ventral surface of thorax golden yellow in color. Forewings uniformly dark brownish-black,

thyridium and arculus and the corneous spots in base of cell  $R_4$  and in thyridial cell behind the thyridium are conspicuously white; hind wings dusky black. Wing venation typical for the genus. Cell 1  $A_2$  comparatively short, not reaching half way to arculus. Femora of all legs golden, spines black, spurs orange-brown. Tibiae of hind legs black, except for apical third which is golden colored; tibiae of other legs and all tarsi black. Spur count 1-3-4.

Genitalia as in Fig. 2. Plates of tenth tergite short and broad as compared to other species; cerci narrow and club-shaped (dorsal view). Claspers two segmented, very long and only slightly curved mesad; basal segment does not have a mesal spine or tuberculus process. The aedeagus is strikingly different from that of all other species of the genus. The sheath of the penis consists of a pair of long, rod-like, dorsolateral, sclerotized appendages which extend slightly beyond the apex of the penis. These appendages are nearly straight with the spine-like apex curving slightly ventrad at the extreme apex; a short distance from the apex and on the ventral side there is a short, appressed spine.

*Female*.—Unknown.

*Holotype*.—Male, Mt. Rainier, Pierce County, Washington, August 9, 1930; in collection of Illinois Natural History Survey, Urbana, Illinois.

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PACIFIC SCIENCE. This journal, now in its third volume, began publication with the January, 1947, issue. It is a quarterly, "devoted to the biological and physical science of the Pacific region," and accepts contributions in that field from authors in all parts of the world. Volume I contained 260 pages, volume II, 315 pages, and the first three numbers of volume III, 280 pages. Publication is by the University of Hawaii, Honolulu, and the present editor is Dr. Leonard D. Tuthill. The subscription price is \$3.00 a year.

To date, only one strictly entomological paper has been published in its pages, namely, "The Pupae of the Mosquitoes of New Guinea," by George Henry Penn, reviewed in this issue of the ANNALS. However, other articles have contained some entomological material or are of interest to the entomologist. Among these may be mentioned two articles by Joseph E. Alicata on the parasites of domestic animals in Hawaii (Vol. I, pp. 69-84, 1947) and in Micronesia (Vol. II, pp. 65-66, 1948), one article by Hubert S. Hurlbut on arthropods of medical importance in the Carolines (Vol. III, p. 278), two articles by Robert W. Hiatt on Crustacea (Vol. I, pp. 241-242, 1947, and Vol. II, pp. 134-213, 1948), and a list of the scientific institutions in the Pacific area, by O. A. Bushnell (Vol. II, pp. 243-261, 1948). A section devoted to shorter notes contains detailed accounts of expeditions, proposed or completed, and other material of direct or indirect interest to entomologists.

Biologists have been making better use of this publication than physical scientists, as indicated by the fact that, to date, leading articles in the biological sciences run to about four times as many pages as those in the physical sciences.

—M. T. J.

## NEW NORTH AMERICAN TABANIDAE (DIPTERA)

### PART I. PANGONIINAE

CORNELIUS B. PHILIP

Hamilton, Montana

The following additions to the Nearctic tabanid fauna (including Part II to follow) bring the total previously cataloged (Philip, 1947) up to 480 species and 39 subspecies, including synonymy and corrections contributed in a supplemental paper (Philip, 1949). Of these, 15 species, mostly of *Tabanus*, remain unrecognized. As stated in that paper, most of the subspecies listed were originally proposed as varieties, which would be the proper biological level for the majority such as my *atricorpus*, *xanthas*, and *mixis* proposed hereafter since they represent, at most, only extreme variants from the typical form. The Rules are unsatisfactory in not recognizing the taxonomic validity of "variety" and so in the Catalog and here the usually less desirable category "subspecies" has been consistently used. Holotypes and allotypes of the following are in the collection of the author unless otherwise indicated.

#### *Apatolestes rossi*, n. sp.

Body and legs uniformly brown. Frons broad, divergent below, yellowish and with a shining yellow inflation below. Wing hyaline without clouds, but with slightly tinted costal cell.

*Holotype* ♀, 11.5 mm. Front 1 : 1½, yellowish, subshining to the vertex on which the ocelli are prominent, with sparse white hairs laterally, and a yellow prominent inflation below, the lower margin almost straight across; cheek not more prominent than face, with sparse black and pallid hairs. Antennae with basal segment reddish, the flagellum black. Palpi concolorous with the face, about two-thirds the length of the proboscis, covered with intermixed black and white hairs.

Thorax and scutellum uniformly brown with two fine submedian pale lines and paler areas above the wing bases, the pleura and the femoral and coxal hairs pallid. No marked hind-tibial fringe, but coarse black hairs on the outer margin.

Abdomen brown, with no marked pattern, though the incisures of tergites 2 and 3 and of sternites from 2 on are noticeably pale-pollinose. Venter covered with pale hairs.

Hullville, Lake Co., Calif., 14 June, 1917, "Blaisdell Collection." In the California Academy of Sciences.

*Allotype* ♂, 13.5 mm. Head markedly wider than thorax, the enlarged facets of the eyes sharply demarkated, occupying the upper three-fourths. Ocelli prominent on a tan-pollinose, elevated, occipital tubercle. Frontal triangle creamy-pollinose, not protuberant. Face whitish-pilose and pollinose, the cheeks not swollen, but with a few brown hairs intermixed with numerous white ones. Scape and pedicel

creamy, with white and a few dark hairs above; flagellum black. Palpi creamy with white pile and a few black hairs apically, elongated to at least three-fourths the length of the proboscis, terminating bluntly with subterminal ridges that give them a moderately clavate appearance distally.

Thorax as in the female; pile overall, including the coxae, whitish, with some sparse brownish ones intermixed dorsally; scutellum concolorous. Legs brown, the tibiae appearing a little darker than the femora because of short appressed black hairs, but no hind-tibial fringe. Wings (somewhat teneral) hyaline, no clouds, the costal cells slightly tinted.

Abdomen brown, black-haired above with incisures of tergites 2 on narrowly pale pollinose and pilose, the incisures widening laterally and a little mesally on tergites 2 to 3 to form low triangles. Venter brown, entirely pale-haired except a few dark hairs caudally, the incisures narrowly pale-pollinose.

Taken with holotype. In California Academy of Sciences.

The species has some affinities to *affinis* Philip but the front of the female is broader and with marked yellow basal inflation. The male could be the "*comastes* form" keyed by the writer in 1941.

#### *Apatolestes affinis* Philip

*Neallotype* ♂, 12 mm. The brown scutellum, general color of body and legs, and subhyaline wings with faint clouds and tinted costal cells associate this with the female, though the dorsum of the thorax and bases of some tergites and the last three sternites are darker. Head not as large proportionately as *rossi* and some other species, the area of moderately enlarged facets about two-thirds the total area of the eye. Frontal triangle, face, and cheeks brown-pollinose, the cheeks moderately swollen below with sparse black hairs and white pile which continues onto the depressed face where there are no black hairs. First two antennal segments brown, the flagellum black. Palpi brown with black and pale hairs intermixed, somewhat produced and subclavate apically rather than truncated. A thin, pale median and two brown submedian lines on the cinereous disc of the thorax; the shoulders and pleura broadly brown. Pleural and coxal vestiture predominantly creamy with a few black hairs. Femora with some shadows darker brown than the tibiae, hind pair entirely pale-haired, hind tibiae shaggy black- and yellowish-haired but not fringed. Abdominal incisures yellowish-pollinose and pilose, black-haired dorso-basally on the segments, entirely pale-haired below except at the tip.

San Fernando, Lower Calif., 19 July, 1938. Mickelbacher and Ross. In the California Academy of Sciences.

#### *Chrysops frigida* Osten Sacken

This northern, transcontinental species has always been accepted as unusually variable in size and color. Over-reliance has been placed on the specificity of the combination of broad apical wing-spot and the black face with three yellow pollinose stripes. The typical form based on the lectotype female from Sharon Springs, N. Y., is dark in overall

appearance, the integument of the face and coxae black, femora with brownish shades, and reddish on the abdomen confined to the sides of the first two tergites, the incisures narrowly pale-pollinose overlying dark integument. Variations occur in series both in the direction of melanism (as in the "Sask." cotype, labelled by Osten Sacken as "type of description") and of albinism. Melanistic variants with practically no red on the abdomen are readily keyed and associated, but a review of more pallid forms reveals specimens of both sexes, with yellow faces and legs, that will not run in any available keys, as well as a large banded-appearing form that the writer regards as comprised of two specifically distinct forms. The type of *C. canadensis* Kröb., on which Dr. G. E. Shewell has made further comparisons and notes for me, is a male of true *C. frigida* as previously surmised.

Though a varietal name would have been more suitable, for taxonomic validity a subspecific name is provided for the extremely pallid form which will have to be keyed separately from darker *frigida*, though complete intergradation has been seen in each or all of the yellowing of the face, abdomen and legs.

#### ***Chrysops frigida xanthas* n. subsp.**

The extreme yellow form of *frigida* in which the face between the lateral pollinose stripes, the lower cheeks at the oral margins, all of the legs including coxae but excepting the trochanters, knees, and tips of the tarsi, are yellow, and the abdomen also is predominantly so though the pattern varies.

*Holotype* ♀, 7 mm. Front taller than wide, yellow-pollinose, the ocellar tubercle and frontal callosity black. Face yellow with a dark shadow along the sutures and three broad, yellow-pollinose stripes, convergent but not connected below, and, including the middle one, reaching the oral margin. Cheeks black, sparsely yellow-pollinose at the oral margin. Antennae with scapes yellow, pedicels and bases of the flagella brown, blackish distally. Palpi yellow.

Thorax greenish-yellow pollinose on the disc flanked by a dark stripe on either side and with a yellow stripe above each wing base along the shoulders. Pleura chiefly golden-yellow pollinose and pilose with the usual underlying narrow dark stripe above and below. Scutellum dark with sparse golden-yellow hairs concolorous with those on the disc of the thorax. Wings as in typical *frigida*, the hyaline triangle reaching but not crossing the furcation. Cell R hyaline over its distal third except the extreme apex, and cell 2nd M hyaline, its distal two-thirds with an extension basad along the hind margin. Crossband widely separated from the hind margin and crossing the base of cell Cu<sub>1</sub>. Halteres yellow.

Abdomen covered with yellow pollinosity and sparse appressed yellow hairs, no black ones; small transverse macules beneath the scutellum on tergite one and isolated in the middle of tergite 2; paired subquadrate dark shadows beneath the pollinosity on 3 and 4, but continuous across the middle of each of 5, 6, and 7, the incisures of all very narrowly pale yellow. Venter yellow with dull, dark shadows basally on tergites 5 and 6.



Hamilton, Ravalli Co., Mont., 15 July, 1939. C. B. Philip, "sweeping" (in marsh grass).

*Allotype* ♂, 5.5 mm. Like the female except for the usual sexual differences and more extensively yellow abdomen. Eyes contiguous for a considerable distance; antennae yellowish to the apical third of the basal annuli of the flagella; the midfacial pollinose stripe also continuous to the oral margin. Thorax plumbeous on the disc with a yellow lateral stripe along each side above the wing base. Scutellum dark. Wings as in the female except the infuscation in the two basal cells occupying almost three-fourths their proximal area. Halteres and legs yellow as in the female. Abdomen entirely bright yellow above and below except for a reduced brownish transverse spot behind the scutellum on each of the first two tergites. The whole body covered with golden yellow hairs, most dense on the sides of the thorax, except for a few dark hairs on the abdominal spots.

Same data as the holotype.

*Paratypes*, 5.5–8 mm. One ♂ and 3 ♀ ♀ same data, 1 ♂ and 1 ♀ same place, 3 June, 1934, W. L. Jellison; 1 ♀, same place, 1 July, 1949, C. B. Philip; 1 ♀, Hamilton "on building," 6 July, 1934, C. B. Philip, and 1 ♀, Gallatin Mts., Montana, 6 August, 1926, C. B. Philip; 1 ♀, Franconia, N. H., Acc. 26226, Coll. Mrs. A. T. Slosson; 1 ♀, Milford, N. H., 8 July, 1906, C. P. Whiting; 1 ♀, Aweme, Man., 4 June, 1926, R. D. Bird. In essential agreement, though occasional brown shadows occur along or outside the facial sutures (in different lights dark underlying tissue may show blackish through the yellow, translucent, bare facial integument in some specimens including the holotype), and the abdominal maculations vary in reduction, most showing a tendency toward two rows of isolated or narrowly connected (geminate) sub-mesal spots on tergites 3 and 4 (and on 5 and 6 in two specimens). The abdomens of some of the paratypes are thus much more extensively yellow in appearance than the holotype. The midfacial pollinose stripe varies in extension downward and the holotype of *xanthas* is the only specimen of *frigida* the writer has seen with it complete to the oral margin. *C. abata* Phil. is the only other instance in the Nearctic fauna in which the stripe is complete in the female and yet predominantly separated from the lateral stripes also (a second specimen in USNM from Orlando, Fla., confirms this condition in the holotype of *abata*). The extent of the basal infuscation in Cells R and 2nd M varies slightly in different specimens. In the collections of the United States National Museum, Canadian National Museum, American Museum of Natural History, Museum of Comparative Zoology, Pennsylvania Department of Agriculture, Harrisburg, Cornell University, L. L. Pechuman, and the author.

Two males taken by sweeping in the type location in 1931 (Larson) agree except they have black facial integument, while a female from Massachusetts, with very yellow abdomen and geminate spots on tergites 3 and 4 very reduced, has only suggestions of yellow color margining the pollinosity of the upper face, and yellow legs. Occasional specimens of the typical form have been seen in which brown or yellow shadows also show up on the femora and even fore coxae. In eastern males studied, in which the yellow on the sides of the abdomen becomes

expansive, the central maculations form a row of inverted trapezoidal or half-moon figures, and narrower spots on the venter subtending from the anterior margins of the segments, but not emarginated to form geminate figures, as in most paler *xanthas*.

On the other hand, intergrades have not been found with the following two distinct forms. The conspicuous yellow and black banding of the abdomen remains transverse and continuous across each tergite, never showing tendencies toward gemination, or complete separation in the middle as in true *frigida*.

#### *Chrysops asbestos* n. sp.

A medium to large, bright-yellow and black, northwestern species with transversely-banded abdomen, black face, coxae and femora, and wing picture resembling *C. frigida* but with the hyaline triangle crossing the furcation rather broadly in the females.

*Holotype* ♀, 9 mm. Eyes in life with occipital border contiguous but the other maculations separated from the margin, the arrowhead with a short shaft above and connected in front to the median spot. Front taller than wide, grayish pollinose across the middle; the vertex for its full width and the large callosity piceus. Face and lower cheeks also shining, piceus with three creamy pollinose stripes convergent below, but only the two lateral ones reaching the oral margins. Antennae normal, the scapes yellowish, the pedicels a little shorter, brown, darker above, the flagella blackish except at extreme base, subequal in length to the two basal segments. Palpi brown above, paler beneath.

Disc of thorax and scutellum blackish with a wide median and two lateral stripes plumbeous anteriorly with sparse yellow hair deepening to a dense deep yellow tuft laterally. Pleura with two grayish-yellow-pollinose stripes, with golden-yellow hair beneath the wing bases. Coxae and femora black with yellowish hairs, the two hind pairs with indefinite brownish tints dorsally. Tibiae and tarsal segments reddish-brown, darker distally, the fore pair darker on the distal half.

Wings with apical spot narrower than in *frigida* and just entering the upper outer corner of cell  $R_4$ , the hyaline triangle almost reaching vein  $R_{2+3}$  at its juncture with the crossband (Fig. 1a). Latter with outer margin somewhat irregular (but no tooth reaching the bifurcation), not reaching hind border, an extension a little over half-way along vein  $M_1$ , receding in cell  $M_4$ , and paler across the base of cell  $Cu_1$ . Cell R infuscated in the basal half and extreme tip with shadows along the discal ridge; cell 2nd M mostly hyaline with a diagonal dash in the upper basal fifth, anal area hyaline. Anal cell narrowly open. Halteres blackish.

Abdomen broad and but little tapered behind; bright yellow with blackish maculations as follows: on tergite 1, a spot as wide as the scutellum, tapered behind and resting broadly on the hind margin; on tergite 2, separated narrowly across the incisure from the above, a subtriangular spot with rounded apex above and base in the middle of the segment and about two-thirds the width of the scutellum; tergites 3 and beyond with broad, sharply demarkated, basal bands, leaving the posterior margins broadly yellow, that on 3 sinuous, gently incised mesally to the center of the tergite, and abbreviated on the extreme

outer edge. Sternites 1 and 2 yellow, sternite 3 with a rather narrow, irregular, but continuous basal band nearly reaching lateral edges, sternite 4 and beyond black with broad yellow incisures. Abdomen covered with bright yellow hair above and below, except on maculations, and sparsely behind the triangle in tergite 2 where the hairs are dark.

Ravalli Co., Mont., 4 August, 1948, C. B. Philip. "On mule in Ross' Hole."

*Allotype* ♂, 8.5 mm. Eyes with inner margins rounded, barely touching at point of maximum arc, leaving a shining black interval below and the prominent, hairy, black ocelligerous tubercle above; the grayish yellow pollinosity on the lower frontal triangle and about the bases of the antennae connects with the midfacial stripe which is more extensive than in the female, reaching the oral margin and practically joining the lateral stripes. Body coloration very like that of the female with which it is readily associated, but the yellow is deeper and the thorax is much darker on the disc and much more golden-yellow hairy. Legs as in the female, coxae and femora likewise black.

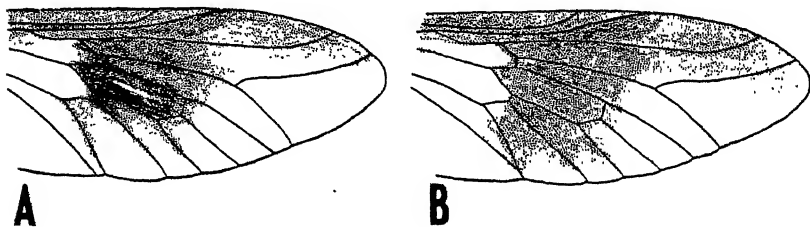


FIG. 1. Wing patterns of *Chrysops asbestos* n. sp. (A), and *C. venus* n. sp. (B).

Wings with apical spot broader, crossing rather faintly into cell R<sub>4</sub> just beyond the furcation but continuing along the upper margin; the apex of the hyaline triangle narrowly envelopes the furcation nevertheless. Cell R hyaline in the apical fourth except extreme tip, cell 2nd M with infuscated streaks on the upper and lower margins for three-fourths and one-half its length, the central portion subhyaline nearly to the basal third. Halteres with blackish stem, brown knobs. Middorsal maculation on tergite 2 larger than in the female, semi-circular behind, nearly reaching the hind margin, and resting broadly on the anterior margin for a distance about equal to the width of the scutellum and wider than the spot on tergite one where they join. The black basal transverse bands on tergites 3 and 4 have crescentic hind margins, that on 3 not quite reaching the lateral margins. The contrasting yellow incisures of tergites and sternites from 3 on produce a banded appearance similar to the female; sternites 1 and 2 have midventral spots not joined at the incisures.

Gold Lake, Sierra Co., Calif., 5 August, 1921.

A paratype male in the University of Kansas from Copalis, Washington, 25 July, 1931, R. H. Beamer, is in almost exact agreement, the ventral black a little more extensive, and the midventral spots on tergites 1 and 2 joined.

*Paratype* ♀♀. One, Mammoth (Lakes), Calif., 19 July, 1933, R. M. and G. E. Bohart; 1, "O.R.J., Seattle"; 2, "W.T." (Wash. Terr.) and West. Wash. Ty., Morrison; 1, Astoria, Ore., 27 July, 1928, K. Gray, J. Schuh; 2, Adel, Lake Co., Ore., 20 July, 1948, #29576, Andy Roth; 1, Lake Tapps, Wn., 10 June, 1936, J. Wilcox; 2, St. Maries, Benewah Co., Ida., 24 June, 1934, C. B. Philip; 1, Alta, Mont., 19 July, 1939, C. B. Philip; 1, Como Lake, Ravalli Co., Mont., 18 July, 1949, McDermott; 1, Lost Horse Canyon, Ravalli Co., Mont., 2 August, 1949, J. White; 1, Elkhorn Sprgs., Beaverhead Co., Mont.; 1, Blue Nose Peak, Lemhi Co., Ida., 5-6 August, 1944, Wm. L. and Wm. H. Jellison; 2, Yellowstone Park, Wyo., July, 1924, V. Argo; 2, Salmon Arm and Monte Creek, B. C., 29 June, 1925, and 7 July, 1929, A. A. Dennys and McFlowry, respectively; 1, Trinity Valley, B. C., 20 July, 1937, H. Cliff; 2, No. Westminster, B. C., 8 July, 1909; 6, Mt. Lehman (Hadwen) and Agassiz, B. C., July. In the United States National Museum, Museum of Comparative Zoology, American Museum of Natural History, Pennsylvania Department of Agriculture, Harrisburg, Canadian National Museum, University of Kansas, Milwaukee Public Museum, California Academy of Sciences, Canadian Livestock Insect Laboratory, L. L. Pechuman, and the author.

The paratypes vary from 8.5-11 mm. in length. Some have the yellow of the abdomen and thorax a deeper golden yellow than in the holotype, the spot on tergite 2 larger and subquadrate, a midventral brown shadow on sternite 2 enlarged in one specimen to a contrasting spot nearly reaching the hind border. In all of the females of *asbestos* the black bands on the abdomen practically or completely cross the entire base of the tergites, and are never divided in the middle or reduced to a geminate condition. In the least melanistic specimen, though the mid-pair of legs is predominantly light brown, the fore coxae do not show yellow streaks seen in some *frigida*, but are uniformly dark brown. The eye patterns are heavy, and the arrowhead has a shaft above which nearly (or completely in one) merges with the occipital border above. In two darker *frigida* and four *xanthas*, though the occipital border is relatively heavy, the other maculations are small and there is no shaft on the arrowhead. In all the *frigida* complex, the border conjoins the occipital margin, but the upper and lower anterior spots are separated from the eye margin.

### *Chrysops venus* n. sp.

Heretofore placed in *C. frigida* O. S.; a rather large, yellow and black banded midwestern deerfly closely resembling the preceding new species in body coloration and wing pattern except the apical spot is broader as in typical *frigida*, the first three sternites are entirely yellow, and the legs are entirely black, except that the mid-tibiae are reddish on their proximal half.

*Holotype* ♀, 10 mm. Head, thorax, and appendages almost exactly match those of the holotype of *asbestos*, though the antennal scapes are a little more robust and the thoracic vestiture more golden, especially at the base of the wings. The eye pattern is also similar, the maculations heavy, the occipital border lying on the margin but the anterior

spots separated from the margin, the median barely separated from the arrowhead, the shaft of the latter not quite reaching the border at the vertex.

The infuscation in the basal cells is the same, but the crossband fills out cells  $M_3$ , Cu, and the apex of the anal cell nearly to the hind-border. Anal cell closed and petiolate. The apex of the hyaline triangle barely envelops the fork of  $R_{4+5}$ , the apical spot crossing  $R_4$  just beyond and filling approximately the upper third of cell  $R_4$  (Fig. 1b).

The abdomen is bright yellow and black, tergite 1 with the black median spot like a flying "V," the wings extending laterad of the scutellum on the base, and barely connecting behind with a transverse reniform spot on tergite 2 which is as wide as the scutellum and slightly emarginate behind, the remaining tergites black with contrasting wide yellow incisures about one-third their width. Venter yellow anteriorly; sternite 4 with a pair of small, isolated, submedian transverse spots; sternites 5 to 7 black with wide contrasting yellow hind margins, the black band on 5 abbreviated laterally.

Vilas Co., Wisc., 10 July, 1913. Through courtesy of Kenneth MacArthur.

*Paratype* ♀ ♀. 1, Copper River, Keewenaw Co., Mich., 17 August, 1930, A. F. Coombs; 1, Cheboygan Co., Mich., 6 July, 1939, Eugene E. Kenaga; 2, Mackinaw Co., Mich., 4 July, 1937, R. R. Dreisbach; 1, Low Bush, Lake Abitibi, Ont., 17 August, 1925, N. K. Bigelow; 2, Temagami Forest Reserve, Ontario, Can. In the United States National Museum, Canadian National Museum, American Museum of Natural History, Milwaukee Public Museum, University of Michigan, University of Kansas, and the collections of L. L. Pechuman and of the author. In close agreement with the holotype, though there is a tendency for the middorsal spot on tergite two to become reduced and subtriangular. The anal cell is closed and usually petiolate in all.

This and *C. asbestos* above have close affinities with *C. quadratus* Meig. of Europe. The last differs in that the apical spot is narrow at its origin but broad apically, and the last three sternites are dark overlain with dull yellowish pollinosity as seen in some typical *frigida*. In *asbestos*, the apical spot is noticeably narrower, the crossband more abbreviated behind, there are midventral maculations on the first two sternites, while sternite 3 has a black, transverse basal band, as on those following. True *frigida* averages smaller in size, and when yellowed as extensively as *venus*, has yellow legs and reduction of the black tergal bands laterally with tendency toward gemination; *venus* is consistent in having the hind tibiae entirely black, and the mid-pair at least on the distal half. Even the darkest *frigida* have these tibiae predominantly reddish.

### *Chrysops upsilon* n. sp.

A southeastern species of the appearance of *C. wiedemanni* with which it has been confused because of the similarity of the thoracic and abdominal patterns, the black frontal and lateral facial callosities, the dark palpi, the yellow legs except the fore tibiae distally and hind

femora basally, and the hyaline basal cells. It is quickly differentiated by the wider apical spot, the almost hyaline costal cell, and the upsilon or T-shaped pollinose marking on the upper face beneath the antennae. The stem of the latter (which is lacking in *wiedemanni*) reaches almost half way to the oral margin on the midfacial, yellow integument. Two paratypes have the lateral black on the face rather broadly joined across and above the oral margin, thus reducing the midfacial yellow. The apical spot of the wing picture, though paler than the crossband, resembles in width darker specimens of *vittata* or *aberrans*. Though there is a hyaline halo around the fork, cell  $R_4$  is almost completely filled and there is usually a diagonal fumose streak between the crossband and wing margin in cell  $R_5$ . Along the juncture of the apical spot with the crossband between the fork and the outer end of the stigma, the infuscation is lighter and narrowly subhyaline in one specimen. The crossband does not quite reach the posterior wing margin along vein  $M_3$ . In addition to the middorsal yellow stripe attenuated on tergite 5, the abdomen of all but two paratypes shows traces of two sublateral yellow stripes on tergites 1 and 2. The anterior sublateral yellow on the otherwise dark venter may stop on sternite 2 or be prolonged onto 3. Length, 7-8 mm. Male unknown.

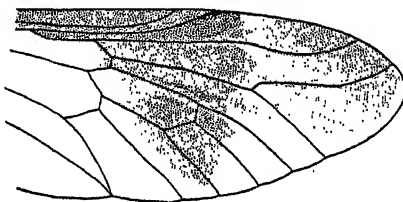


FIG. 2. Wing pattern of *C. upsilon* n. sp.

*Holotype* ♀, Millen, Georgia, 7 September, 1940, Horace O. Lund.

*Paratype*.—3, Coleraine, N. C., July, 1906, R. S. Woglum; 1, Kinston, N. C., 8 July, 1925, C. S. Brimley; 1, Elizabeth City, N. C., late August, 1919, F. Sherman; 1, Calhoun Co., S. C., 12 August, 1944, and 1, Monk's Creek, Berkeley Co., S. C., 29 May, 1944, C. W. Sabrosky; 2, Albany, Ga., 7 and 14, July, 1939, H. O. Lund; 2, Millen, Ga., 21 and 27 June, 1940, H. O. Lund; 1, Smithville, Miss., 15 July, 1930, R. H. Beamer; 1, Lucedale, Miss., 9 Sept., 1929, H. Dietrich; 2, Camp Shelby, near Hattiesburg, Miss., June, 1944, and 3 July, 1943, C. D. Michener; 2, Pontchatoula Beach, Tangipahoa Parish, La., 31 July, 1948, G. H. Penn; 2, Springfield, Livingston Parish, La., 12 August, 1948, G. H. Penn; 1, Fontainebleau State Park, St. Tammany Parish, La., 14 August, 1948, G. H. Penn; 3, Lecompte, La., 25 July, 1906, J. S. Hine; 1, Slidel, La., 2-6 July, 1905, J. S. Hine; 1, Loganport, La., 31 May, 1906, J. S. Hine; 1, Almyra, Ark., September 12, 1911, E. S. Tucker (Bishopp No. 5411). In the collections of the United States National Museum, American Museum of Natural History, Museum of Comparative Zoology, Michigan State College, Emory University, the University of Georgia, L. L. Pechuman, and the author.

True *Chrysops wiedemanni* is uncommon in this area. One female each from Georgia and Mississippi has been seen since the separation of *C. upsilon*. The lack of the midfacial pollinose stripe and the narrower apical spot distinguish these as in the case with the northern specimens.

### *Chrysops wiedemanni* Krober

The first instance of a stylized tabanid to come to the writer's attention is a female of this deerfly from Ann Arbor, Mich., July, 1927, N. K. Bigelow. The cephalic end of a male puparium may be seen protruding between the sides of the third and fourth tergites.

Acknowledgments will be made in the paper on Tabaninae to follow.

### SUMMARY

Described as new are: *Apatolestes rossi* (♀ holotype from California and ♂), *Chrysops frigida* subsp. *xanthas*, n. subsp. (♀ holotype from Montana, and ♂), *C. asbestos* n. sp. (♀ holotype from Montana, and ♂), *C. upsilon* n. sp. (♀ holotype from Georgia), and *C. venus* n. sp. (♀ holotype from Michigan). The ♂ of *A. affinis* is described from Lower California. A stylized *C. wiedemanni* appears to be the first instance of this parasitism noticed in a tabanid.

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THE INSECT WORLD OF J. HENRI FABRE, by EDWIN WAY TEALE (Editor). Dodd, Mead and Company, New York. xvi+333 pages. 1949. Price, \$3.50.

Of course, J. Henri Fabre requires no introduction to the entomologist. The only question that should occur to his mind is, Why should a new edition of Fabre's work be needed at this time? Mr. Teale answers this in the foreword: "The present volume brings into the compass of a single book, the most famous of Fabre's studies, many of them now out of print." We find such studies as the curious death-march of the pine processionary caterpillar, the ball-rolling of the sacred scarab, the mating of the cannibalistic mantid, the remarkable (even though now familiar) story of the burying beetle, and others. In all, forty excerpts are made from Fabre's work. These are in Fabre's language, at times somewhat condensed, but with nothing added except a brief preface to each, by means of which Mr. Teale attempts to set the stage for the reader, especially for the non-professional. The translation is that of Alexander Teixeira de Mattos.

The end papers, lining the inner cover and the first fly leaf, opposite each, are devoted to a well-known portrait of the aging Fabre, an illustration of the house of Sérignan, and a group of insect photographs which are obviously the work of the author of "Grassroot Jungles" and its successors. No other illustrations are used.—M. T. J.

# EMERGENCE OF THE LACEWING, *CHRYSOPA HARRISII* FITCH (NEUROPTERA) AND THREE HYMENOPTEROUS PARASITES FROM THE COCOON<sup>1</sup>

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## MATERIAL AND METHODS

Between July 31 and August 13, 1948, 206 chrysopid cocoons were collected from several Austrian pines on the campus of McMaster University, Hamilton, Ontario. The cocoons had been spun on the pine needles, the majority being situated within an inch of the tip of the needle. Each needle was placed in a shell vial (75 mm. x 15 mm.) in such a manner that the cocoon was well away from the glass, and the needle was held in place by being jammed between the glass and a cork closing the vial. The vials were numbered and placed in trays and were kept at room temperature. They were examined daily and emerging insects were collected and pinned.

## RESULTS

From August 1 to August 25 insects emerged from 176 cocoons, one from each cocoon. The remaining 30 cocoons failed to produce emergents by October 29, when they were discarded. The numbers of the various species of insects which emerged from the cocoons are summarized in Table I. Of the emerging insects, 129 were lacewings which were determined, with the aid of Smith's key (1932), to be *Chrysopa harrisii* Fitch. Representative specimens were examined by Professor Smith who kindly confirmed the identification. The remaining emergents were two ichneumonids, *Gelis tenellus* (Say) and *Otacustes crassus crassus* (Prov.) determined by Mr. H. K. Townes of the U. S. National Museum and one chalcidoid wasp, *Pachyneuron altiscuta* How. (Pteromalidae) determined by Mr. A. B. Gahan of the U. S. National Museum.

### *Emergence of Adults*

The active pupa of a lacewing emerged from the cocoon by pushing open the circular lid (Fig. 1A) and crawling out. It characteristically walked about on the pine needle or on the glass of the vial for from ten to thirty minutes. In some cases the pupa merely emerged from the cocoon and clung to it, not venturing onto the needle. In from ten to thirty minutes after emergence from the cocoon the pupa became quiescent, the dorsal thoracic integument split, and the adult emerged. The time elapsing from this first sign of emergence to the attainment of full expansion of the wings varied from 15 to 45 minutes. During

<sup>1</sup>Contribution from the Department of Zoology, McMaster University, Hamilton, Ontario.



this process the adult voided a black pellet of larval excrement about 1 mm. x 2 mm. in size. Eleven of the pupae, though successful in emerging from the cocoon, failed to go through the final moult and produced no adults. Smith (1922) reports that the period of moulting after emergence from the cocoon is the most critical in the life history and accounts for a fatality of 30% to 60%. In the present study 11 of the 129 pupae failed to produce adults—a fatality of 8%.

TABLE I

NUMBERS OF *Chrysopa harrisii* AND PARASITES WHICH EMERGED FROM COCOONS

Date	<i>Chrysopa harrisii</i>			<i>Gelis tenellus</i>		<i>Otacustes c. crassus</i>		<i>Pachyneuron altiscuta</i>
	Males	Females	Pupae	Males	Females	Males	Females	
Aug. 1	1	.....	.....	.....	.....	.....	.....	.....
2	5	.....	.....	.....	.....	.....	.....	.....
3	8	6	2	.....	.....	.....	.....	.....
4	6	2	1	.....	.....	.....	.....	.....
5	9	.....	1	.....	.....	.....	.....	.....
6	3	6	1	.....	.....	.....	.....	.....
7	7	7	1	.....	.....	2	1	.....
8	6	5	1	.....	.....	2	1	.....
9	1	5	.....	.....	.....	2	.....	.....
10	6	3	.....	.....	.....	2	.....	.....
11	.....	1	.....	.....	.....	1	2	.....
12	2	3	1	.....	1	6	2	.....
13	1	4	.....	.....	1	2	1	.....
14	3	.....	.....	.....	4	2	1	.....
15	.....	.....	.....	1	2	.....	.....	.....
16	1	3	1	.....	1	1	1	.....
17	2	.....	.....	.....	.....	.....	1	.....
18	5	2	1	.....	1	.....	.....	.....
19	1	1	.....	.....	2	.....	.....	.....
20	1	1	.....	.....	.....	.....	.....	.....
21	.....	.....	1	.....	.....	1	.....	.....
22	.....	.....	.....	.....	1	.....	.....	.....
23	.....	.....	.....	.....	.....	.....	.....	.....
24	1	1	.....	.....	.....	.....	.....	1
25	.....	.....	.....	.....	.....	.....	.....	1

The ichneumonids *Gelis tenellus* and *Otacustes c. crassus* left the cocoon through a ragged hole about 1 mm. in diameter (Fig. 1B) perforating the cocoon near its free end or along its side. The adult insect immediately walked rapidly about in the vial, tapping the surface of the glass actively with the antennae. The adults of *Pachyneuron altiscuta* emerged from the cocoon through a ragged hole about 0.5 mm. in diameter (Fig. 1C) and flew or walked about actively in the vial.

The first emergence of the lacewings occurred on August 1, the peak of emergence on August 3, and the last emergence on August 24 (Fig. 2E). The males first emerged two days before the females and reached their peak of abundance two days before that of the females (Fig. 2F, G).

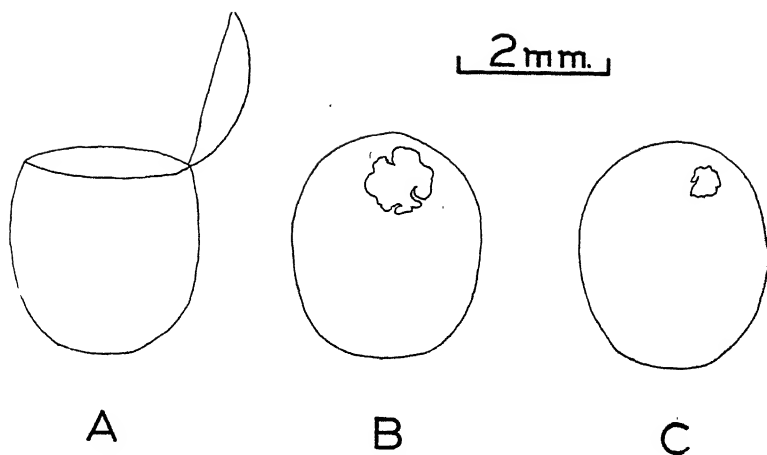


FIG. 1. A. Cocoon of *Chrysopa harrisii* showing opened lid. B. Cocoon showing hole made by emerging adult ichneumonid. C. Cocoon showing hole made by emerging adult of *Pachyneuron altiscula*.

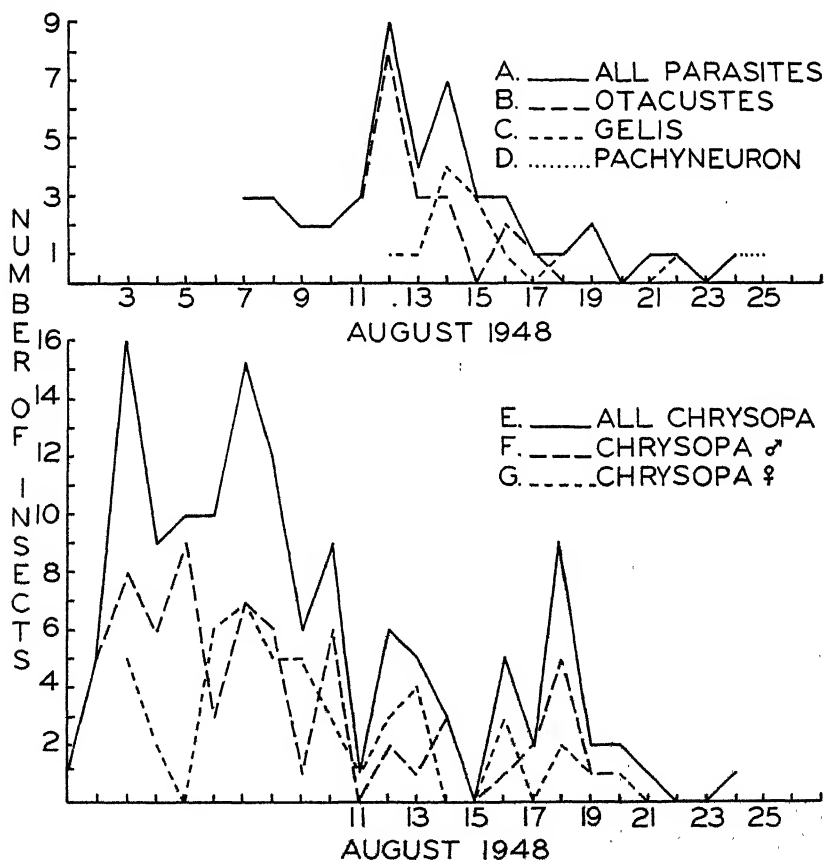


FIG. 2. Graphs showing periods of emergence of *Chrysopa harrisii* and hymenopterous parasites.

The first parasite to appear was *Otacusies c. crassus* which emerged first on August 7, a week later than the first emergence of the chrysopid (Fig. 2B). It reached a peak of abundance on August 12. The first emergence of *Gelis tenellus* occurred on August 12 (Fig. 2C) and this species reached its peak of abundance on August 14. The two specimens of *Pachyneuron altiscuta* emerged on August 24 and 25 (Fig. 2D), and were probably hyperparasites.

### Sex Ratios and Percentage of Parasitism

Forty-seven of the 176 cocoons which produced emergents were parasitized—a parasitism of 26.7%. Of this total, 17.6% is accounted for by *Otacusies c. crassus*, 7.9% by *Gelis tenellus*, and 1.2% by *Pachyneuron altiscuta*.

The sex ratios of the chrysopid and of the parasites are summarized as follows:

	Males	Females	Total	% of Males	% of Females
<i>Chrysopa harrisii</i> .....	68	50	118	57.6	42.4
<i>Gelis tenellus</i> .....	1	13	14	7.1	92.9
<i>Otacusies c. crassus</i> .....	21	10	31	67.7	32.3

The sex of the chrysopids was determined by comparing specimens with Smith's diagrams of the terminal segments of a chrysopid (Smith, 1922) and by comparison with specimens whose sex had been determined by Dr. Smith. The sex of the eleven pupae which failed to produce adults was not determined.

All specimens of the lacewing and of the three parasites are retained in collections at McMaster University except one of *C. harrisii* kept by Professor R. C. Smith of Kansas State College.

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### THE PUPAE OF THE MOSQUITOES OF NEW GUINEA, by GEORGE HENRY PENN. Pacific Science, vol. 3, pages 3-85, 58 figures. 1949.

The voluminous recent work on mosquitoes has to a large extent neglected the pupal stage, probably because, in view of the ease of rearing adults from pupae, determinations can be made without consideration of that stage. The author, however, finds pupal characters, for the New Guinea fauna, relatively constant for a given species, and considers an examination of this stage a valuable adjunct in mosquito taxonomy, as well as an aid in the solution of some puzzles regarding species relationships and phylogeny. Of the 196 species of mosquitoes recorded from New Guinea, 68 are now known in the pupal stage; of these, 32 are described for the first time in this work. Generic and specific keys are included. The descriptions seem to be adequate, and most of them are accompanied by illustrations showing the abdominal chaetotaxy and paddles. The cephalothoracic chaetotaxy and the respiratory trumpets also furnish important taxonomic characters.—M. T. J.

# OBSERVATIONS ON MOSQUITOES BREEDING IN PLANT CONTAINERS IN YUNNAN<sup>1</sup>

C. Y. CHOW

A general survey of the mosquito fauna of the Chefang region in western Yunnan was carried out during the years from 1940 to 1942, at the same time that studies were being made of anophelines and malaria. General observations on the area and on the anopheline mosquitoes have been published by Sweet *et al.* (1942). A list of the culicine species was published recently (Chow, 1949). The object of the present paper is to summarize certain observations made at this time on species with specialized larval habitats in plant containers.

Shannon (1931) proposed that the larval habitats of mosquitoes could be classified according to two sets of factors, one related to the "condition" of the water, the other to its "location." He recognized two major classes according to location: ground depressions (marshes, streams, ponds, etc.) and water containers. These last, the container habitats, constitute the breeding places of a large fraction of the mosquito fauna in tropical regions, though in the temperate zone only one type of container is commonly seen, the tree hole. At Chefang, 92 miles north of the Tropic of Cancer, several types of container habitats are found, with a varied mosquito fauna. In the vicinity of Peiping, in temperate-zone China, tree holes form the only container habitat, and only four mosquito species breed in these (Feng, 1938).

Few special studies of the ecology of container habitats have been made in the Orient. Wijesundara (1942) has shown how productive such habitats may be in Ceylon. He reports that 1,420 mosquitoes representing 19 species were reared from larvae in 29 water samples taken from tree holes, and 1,352 mosquitoes representing 17 species from larvae in 23 samples from stumps of the giant bamboo. At Chefang, my associates and I found mosquitoes breeding in tree holes, bamboo stumps, and the leaf axils of five different kinds of plants.

## TREE HOLES

Six holes were found in four different trees in the vicinity of Chefang. The holes were all large, averaging about a meter in diameter and 15 cm. in depth; they were all high, 6 meters or so above ground. Rain water began to collect in these holes after the middle of April and remained continuously throughout the rainy season, that is, until October. Some large holes still had water at the end of the year. Fortnightly collections were made from these holes during the rainy season.

<sup>1</sup>The studies herein reported were carried out under the auspices of the National Institute of Health of China in cooperation with the International Health Division of The Rockefeller Foundation. I am indebted to Professor L. C. Feng of the Peiping Union Medical College, Peiping, China, for his valuable suggestions and help. I want to express my special thanks to Dr. Marston Bates, of The Rockefeller Foundation, for help in the preparation of the manuscript. Cost of publication is paid by the Rockefeller Foundation.

The larvae found in these holes were: *Megarhinus splendens* (Wiedemann), *Orthopodomyia anopheloides* (Giles), *Aedes* (*Finlaya*) *albolateralis* (Theobald), *A. (F.) dissimilis* (Leicester), *A. (F.) harveyi* Barraud, *A. (F.) assamensis* (Theobald), *A. (Stegomyia) albopictus* (Skuse), *A. (S.) annandalei* Theobald, *Culex* (*Neoculex*) *brevipalpis* Giles, and *C. (Culiciomyia) pallidothorax* Theobald. Of these, *A. albopictus* was the commonest species, being found in nearly all the holes on all visits, whereas *A. assamensis*, *A. annandalei* and *A. albolateralis* were comparatively rare, and the others very rare, especially *M. splendens*, of which only one specimen was found during the two years.

The fact that only the larvae of *A. albolateralis*, *A. assamensis* and *A. albopictus* appeared within the first few days after rain water collected indicates that the eggs of these species had overwintered in the holes.

*Orthopodomyia anopheloides* appeared at the beginning of July and was still present at the end of the year. The larval color of this species is brownish red so that it seems to have some adaptation to the environmental condition, as the water in the breeding place is, mostly, a deep brownish red in color. By this larval color character, the species can be easily differentiated with the naked eye from other species.

Several species have been frequently found in the same tree hole at the same time, an exception being *O. anopheloides*, which usually breeds singly. There seemed to be no relation between kind of tree and species of mosquito breeding in its rot holes.

The larvae collected from the tree holes were raised in small tubes with water from the habitat. No fresh water was added, and the tubes soon became fouled with mould. This did not, however, interfere with the development of the larvae.

#### BAMBOO STUMPS

Bamboo is the commonest plant in the region and is much used by local Shan people. Bamboo stumps begin to fill with rain water in the middle of April. Most of them become dry after the rainy season, but at the end of the year we still found some larvae in the bigger stumps which held water from the December rains. The stumps, which were cut off from 70 to 170 cm. above ground, varied from 10 to 27 cm. in diameter and 12 to 30 cm. in depth. Water filled the stump to about one-third of its depth.

Mosquito larvae were found very frequently in the old stumps where the water was very foul with rotten leaves and debris; whereas, in the newly cut stumps where the water was rather clear almost no larvae could be found. Whether or not the female mosquito will deposit her eggs in the newly cut stumps and whether or not the larvae can develop there is unknown. The odor of the newly cut stumps might have some influence in deterring the female mosquitoes from laying their eggs.

The larvae found were *Megarhinus graveli* Edwards, *Tripteroides aranoioides* (Theobald), *Uranoiaenia obscura* Edwards, *Heizmannia greeni* (Theobald), *Aedes* (*Finlaya*) *albolateralis* (Theobald), *A. (F.) harveyi* Barraud, *A. (F.) formosensis* Yamada, *A. (F.) assamensis*

(Theobald), *A. (F.) albotaeniatus* var. *mikiranus* Edwards, *A. (Stegomyia) annandalei* Theobald, *A. (S.) albopictus* (Skuse), *A. (S.) w-albus* Theobald, *Armigeres (Armigeres) kuchingensis* Edwards, *Armig. (Leicesteria) magnus* (Theobald), *Armig. (L.) flavus* (Leicester), *Armig. (L.) annulipalpis* (Theobald), *Culex (Lophoceratomyia) minor* Leicester and *C. (L.) uniformis* Theobald.

Larvae began to hatch out after the beginning of May. *Aedes albopictus* appeared first. One month later, the genera other than *Aedes*, like *Tripteroides*, *Armigeres*, and *Megarhinus*, began to appear. At the end of the year *Armigeres* species and *Aedes albopictus* still could be found in some of the big bamboo stumps.

The larvae of *Armigeres* curve the body more strongly in movement than other larvae, and swim backward. They are not predaceous, but feed on debris in the bottom of the stump. They are in almost constant movement, resting only briefly at the water surface for breathing, where they maintain the body perpendicular to the surface.

#### LEAF AXILS

1. *Banana*.—From the middle of May rain water collected at the bases of the leaves of banana plants, and after two weeks *Harpagomyia genurostris* (Leicester) larvae of various stages appeared. Only this species was found in the two years. The water dried up immediately after the rainy season was over.

The larvae are of a greenish-white color and somewhat transparent. They always straighten their bodies to move upward and downward, and spend more time at the bottom of the water than at the surface.

2. *Pineapple*.—Only *Harpagomyia genurostris* (Leicester) was found in water collected in pineapple plants. Some water was found in the leaf bases after the rainy season as a result of December rains, but no larvae were present.

3. *Aroid*.—An aroid resembling *Colocasias* grew wild in the region. This plant held less water than banana and pineapple plants; the water did not collect until June, and larvae did not appear until July. The water was clear. Larvae of two species, *Harpagomyia genurostris* (Leicester) and *Topomyia houghtoni* Feng, were found.

*Topomyia houghtoni* was collected from this plant in 1940 and described by Feng (1941) as a new species. The larvae are of a greenish-white color, except for the head, which is black. They straighten their bodies like *Harpagomyia genurostris* to move forward and downward. They have a tendency to remain at the bottom of the water for several minutes. They are predaceous in habit and feed on the larvae of other species (*genurostris*) which are in the same breeding place. In the absence of larvae of other species they become cannibalistic. The feeding habit, as Feng (1941) described, is as follows:

"The larva usually lies, with its ventral surface upward, quietly at the bottom of the water and waits for its prey. As soon as another larva comes within its reach, this is caught between the two maxillae. The mandibles will crush the prey between the mental plate, and the soft parts are thus swallowed. The larva, however, does not seem to hunt for its prey as do the larvae of *Lutzia* or *Megarhinus*."

4. "Tun-tun."—This is a plant about 3 meters high with large, long, hard, spiny leaves which stretch upward at an angle of 45° to the stem, so that water can collect at the leaf bases. Water was present from the middle of June, and larvae were found a month later. *Harpagomyia genurostris* (Leicester), *Aedes albopictus* (Skuse) and *A. formosensis* Yamada were found. The adults of *genurostris* rest on the stem of the plant where many big ants are climbing about. I could

TABLE I

SUMMARY OF CONTAINER BREEDING OF CHEFANG MOSQUITOES;  
CROSSES INDICATE RELATIVE ABUNDANCE

	Tree- holes	Bam- boo stumps	Banana	Pine- apple	Aroid	"Tun- tun"	"Mou- in-ka"
<i>Megarhinus gravelyi</i> .....	+	+	.....	.....	.....	.....	.....
<i>M. splendens</i> .....	+	+	.....	.....	.....	.....	.....
<i>Tripteroides aranoioides</i> .....	.....	++	.....	.....	.....	.....	.....
<i>Topomyia houghtoni</i> .....	.....	.....	.....	.....	+	.....	.....
<i>Harpagomyia genurostris</i> .....	.....	.....	+	+	+	+	.....
<i>Uranotaenia obscura</i> .....	.....	+	.....	.....	.....	.....	.....
<i>Orthopodomyia anopheloides</i> .....	++	.....	.....	.....	.....	.....	.....
<i>Aedes</i> (F.) <i>assamensis</i> .....	++	++	.....	.....	.....	.....	.....
<i>A.</i> (F.) <i>albocinctus</i> .....	+	.....	.....	.....	.....	.....	.....
<i>A.</i> (F.) <i>albotaeniat</i> var. <i>mikiranus</i> .....	.....	+	.....	.....	.....	.....	.....
<i>A.</i> (F.) <i>harveyi</i> .....	+	++	.....	.....	.....	.....	.....
<i>A.</i> (F.) <i>formosensis</i> .....	.....	++	.....	.....	.....	.....	.....
<i>A.</i> (F.) <i>dissimilis</i> .....	+	.....	.....	.....	.....	.....	.....
<i>A.</i> (F.) <i>albolateralis</i> .....	++	++	.....	.....	.....	.....	.....
<i>A.</i> (S.) <i>annandalei</i> .....	++	++	.....	.....	.....	.....	.....
<i>A.</i> (S.) <i>w-albus</i> .....	.....	+	.....	.....	.....	.....	.....
<i>A.</i> (S.) <i>albopictus</i> .....	+++	+++	.....	.....	.....	++	+
<i>Heizmannia greeni</i> .....	.....	+	.....	.....	.....	.....	.....
<i>Armigeres</i> (A.) <i>kuchingensis</i> .....	.....	++	.....	.....	.....	.....	.....
<i>Armig.</i> (L.) <i>flavus</i> .....	.....	+	.....	.....	.....	.....	.....
<i>Armig.</i> (L.) <i>magnus</i> .....	.....	+	.....	.....	.....	.....	.....
<i>Armig.</i> (L.) <i>annulipalpis</i> .....	.....	+	.....	.....	.....	.....	.....
<i>Culex</i> (N.) <i>brevipalpis</i> .....	+	.....	.....	.....	.....	.....	.....
<i>C.</i> (L.) <i>minor</i> .....	.....	+	.....	.....	.....	.....	.....
<i>C.</i> (L.) <i>uniformis</i> .....	.....	+	.....	.....	.....	.....	.....
<i>C.</i> (C.) <i>pallidothorax</i> .....	+	.....	.....	.....	.....	.....	.....

not see that they took food from the mouth of these ants as Jacobson described (Barraud, 1934).

5. "Mou-in-ka."—This is a native plant resembling the century plant (*Agave*). Only *Aedes albopictus* (Skuse) was found breeding in this plant.

#### HIBERNATION IN TREE HOLES AND BAMBOO STUMPS

The dry and winter season extends from December through March. The mean maximum temperatures for these months in the 1940-41 season were, respectively, 26.4°, 24.1°, 26.4°, and 30.0° C.; the lowest

temperatures recorded each month were 7.7°, 2.8°, 4.0°, and 7.1° C. The total monthly rainfall for December was 50.0 mm., for January 5.0 mm., for February 15.0 mm., and for March 3.0 mm. In April, 1941, the rainfall increased to 30 mm., and the mean maximum and extreme low temperatures were 31.4° and 10.8° C.

About the middle of December, 1940, the tree holes and bamboo stumps began to dry out, staying dry throughout the winter season.

TABLE II

SPECIES REARED FROM EGGS IN BAMBOO STUMPS AND TREE HOLES

SAMPLE		<i>albo-</i> <i>pictus</i>	<i>annan-</i> <i>dalei</i>	<i>albo-</i> <i>lateralis</i>	<i>assa-</i> <i>mensis</i>	<i>harveyi</i>	<i>albo-</i> <i>taeniatulus</i>	<i>albo-</i> <i>cinctus</i>
Bamboo stumps	1.....	5					2	
	2.....	3		3				
	3.....		4	1				
	4.....	4			1			
	5.....						2	
	6.....	6					3	
	7.....	10						
	8.....	2						
	9.....	4						
	10.....			1				
	11.....	3				1		
	12.....	13	9	3	3	2		
	13.....	7	3					
	14.....	6			1			
	15.....	1		6				
	16.....	1						
	17.....	5		2		1	1	
	18.....		5					
	19.....			2				
	20.....	3	1					
	21.....	3	20	2				
	22.....		11					
	23.....		16	3				
	24.....		1					
	25.....	1						
	26.....			1				
	27.....			1				
	28.....	1						
Tree- holes	1.....	9			15			
	2.....	17						
	3.....	21		11	11			
	4.....							142

From the end of February to the middle of March, 1941, we collected bamboo stumps in different places by cutting off the top section. We also collected the dried debris and rotten leaves from tree holes. All of this material kept dry in the laboratory. On April 10, 1941, when the weather had become warmer, the bamboo sections were filled with water and the tree-hole material was immersed in separate jars. Larvae were first noticed on the following day. They pupated, and adults emerged at different intervals from April 18 to the middle of May.



Many old bamboo stumps were collected, but some of them were broken because of dryness. Water was put in thirty-four good stumps, of which twenty-eight produced larvae. Six species, all belonging to the *Aedes* group, were found. They were *albopictus*, *annandalei*, *albolateralis*, *harveyi*, *assamensis* and *albotaenialis* var. *mikiranus*. The number of the adults hatched out and the association of species are shown in Table II.

Material was collected from four different tree holes, and larvae were recovered in each case. Four species, also all *Aedes*, were found: *albopictus*, *assamensis*, *albolateralis* and *albocinctus*. The data are included in Table II.

#### SUMMARY

Results are given of a survey of mosquitoes breeding in plant containers in the vicinity of Chefang, Yunnan. Eleven species were found in tree holes, 18 in bamboo stumps, 1 in leaf bases of banana, 1 in pineapple plants, 2 in an unidentified aroid, 2 in a native plant called "tun-tun" and 1 in an agave-like plant called "mou-in-ka." These mosquitoes belonged to the genera *Megarhinus*, *Tripteroides*, *Topomyia*, *Harpagomyia*, *Uranotaenia*, *Orthopodomyia*, *Aedes* (*Stegomyia* and *Finlaya*), *Heizmannia*, *Armigeres* and *Culex* (*Neoculex*, *Lophoceraomyia* and *Culiciomyia*).

Material collected from bamboo stumps and tree holes during the dry winter season was tested for hibernating eggs. Seven species were recovered from this material, all belonging to the genus *Aedes*.

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# DIURNAL MOSQUITOES IN AN AREA OF SMALL RESIDUAL FORESTS IN BRAZIL<sup>1</sup>

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AND  
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## INTRODUCTION

An investigation of the epidemiology of jungle yellow fever was undertaken in the vicinity of Passos, Minas Gerais, in the period 1945 to 1948 and has been reported by Laemmert, Hughes and Causey (1). This region was thought to be particularly favorable for such a study because it had been the scene of jungle yellow fever between 1935 and 1938 and appeared to have been in the path of another epidemic which invaded the neighboring state of Goiaz in 1944.

As part of the program, observations were made on the diurnal forest mosquitoes to determine the species present, their relative abundance, and their seasonal and environmental prevalence. In particular, it was intended to secure this information on the species of *Haemogogus* and other potential vectors of yellow fever occurring in that area. It was also proposed to isolate yellow fever virus, if present, from mosquitoes.

## TOPOGRAPHY OF THE PASSOS REGION

Passos is situated near the southeastern border of the State of Minas Gerais, at an altitude of 700 meters, about 10 kilometers from the Rio Grande. Specifically, the location is 46° 38" west longitude and 20° 46" south latitude.

The countryside is characterized by small hills with vestiges of old forest in some deeper valleys and along a few of the ridges and steeper slopes. In addition there are scattered second growth forests. In many of these wooded areas are springs which give rise to permanent meandering streams. Other springs form bogs or marshes in poorly drained areas that remain wet throughout the year. The greater part of the land is cleared and utilized for the grazing of zebu cattle. The principal cultivated crops are corn, sugar cane, beans, rice and cotton. Smaller amounts of coffee and tobacco are grown.

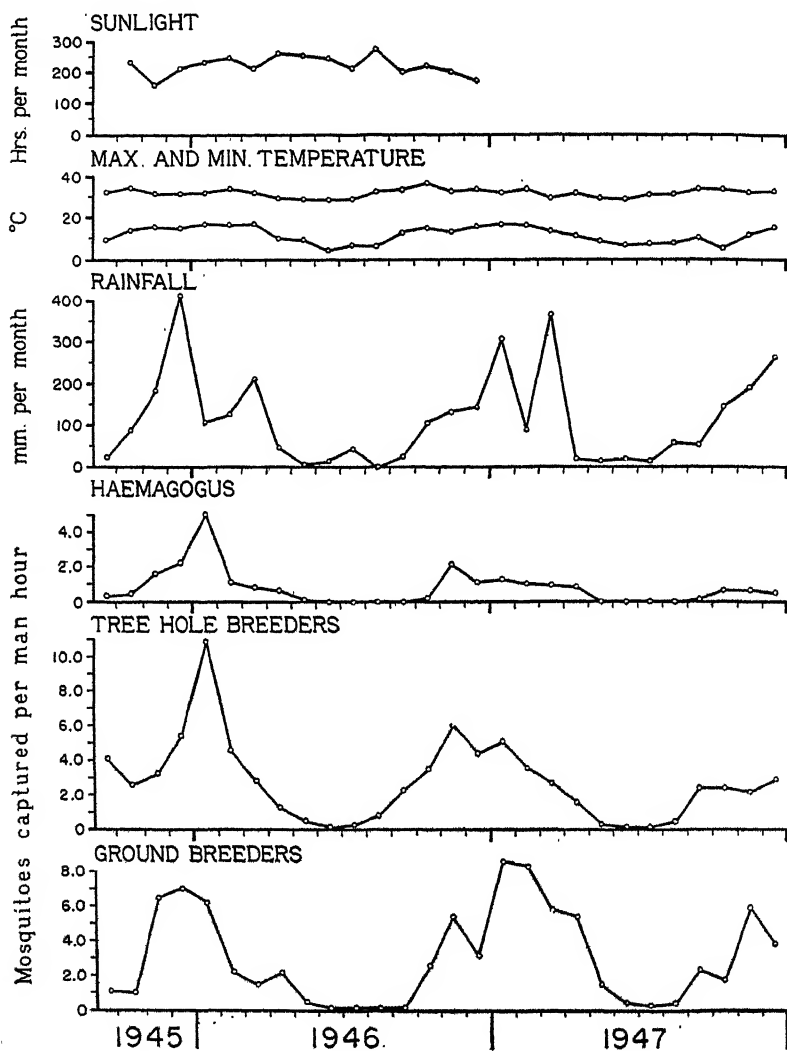
## CLIMATE OF THE PASSOS REGION

The position of Passos north of the Tropic of Capricorn places it within the tropical zone, while its altitude of 700 meters on an interior plateau gives it a modified climate with wide range of daily temperature.

There are two well defined seasons in Passos, consisting of wet-hot and cool-dry periods of approximately six months each. However, the

<sup>1</sup>Studies and observations on which this paper is based were conducted with the support and under the auspices of the "Serviço de Estudos e Pesquisas sobre a Febre Amarela" of the Ministry of Education and Health of Brazil in cooperation with the International Health Division of The Rockefeller Foundation. Cost of publication is paid by The Rockefeller Foundation.

seasons vary from year to year in duration, and while in some years there are occasional showers during the winter months, in other years there may be as many as 7 months without appreciable rainfall. The wettest period occurs between November and March. Total precipita-



GRAPH I

Meteorological data by month, and mosquitoes captured per man hour by month from September, 1945, to December, 1947.

tion for the calendar years 1946 and 1947 was 1,031 mm. and 1,553 mm. respectively. It may be noted that there were more frequent light rains during the dry season of 1947 than in that of 1946, and that the

distribution of heavy rains was not the same in these two years. The wet season usually begins in October. When the period of study is divided into the two complete cycles of seasons from October, 1945, to September, 1946, and from October, 1946, to September, 1947, the total rainfall in each year is seen to be almost identical, being 1,273.9 and 1,331.5 mm. respectively. The total rainfall for each month during the study period is shown in Graph I.

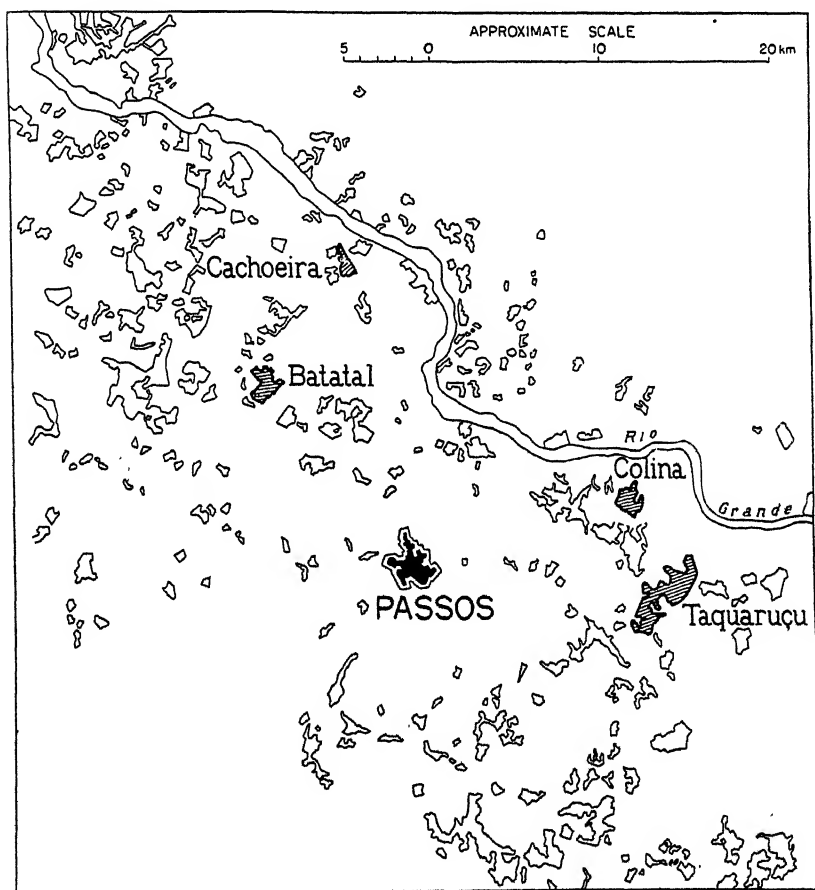


PLATE I

Forest patches in the Passos study area used for routine mosquito captures.

Throughout the period of observation the temperature during the colder part of the dry season, June to August, ranged between an absolute minimum of 4.5° C. and an absolute maximum of 33° C., with an average minimum for those months of 12.2° C. and an average maximum of 26.8° C. During the warmer months, December to February, the temperature reached extremes of 16° C. and 34.1° C.

with an average minimum of 19.2° C. and average maximum of 29.2° C. The monthly maximum and minimum temperatures are shown in Graph I.

The minimum humidity may fall as low as 3 per cent during the dry season but the weekly average humidity ranged between 41.7 and 73.8 per cent for this period. The minimum humidity registered during the wettest months was 16 per cent with a weekly average humidity between 60.8 and 85.6 per cent.

#### DESCRIPTION OF FORESTS AND STATIONS

For this study of diurnal sylvan mosquitoes four old forests from 11 to 16 kilometers distant from Passos were chosen. All of these are typical of the forests in which jungle yellow fever was contracted in the period 1935 to 1938; and in preliminary investigation, all were found to harbor species of mosquitoes known to be efficient vectors of yellow fever. Their location with reference to the city of Passos is shown on Plate I.

A photoecological study of these four forests was made by Veloso (2). He considered two of them, Batatal and Cachoeira, to be remnants of climax rain forests. One of them, Colina, he described as a semi-rain forest, or an area recently invaded by rain forest, and the fourth, Taquaruçu, he recognized as postclimax forest.

In each forest four capture stations designated as A, B, C, and D were chosen. They were situated in the vicinity of large trees, in the older part of the forest. At each station a ladder was constructed on one of the trees and a platform built at a height of eight to seventeen meters. In Batatal the four stations were situated at the bottom and on both of the steep sides of a ravine through which flowed a permanent stream. At Cachoeira the stations likewise were in the vicinity of a stream, but on more gentle slopes than in Batatal, with D at the highest and B at the lowest level. At Colina the stations were situated in the central region of a hillside forest in a section with gentle slope, with D at the highest elevation. At Taquaruçu there was also little incline, with A at the lower and D at the higher elevation, and with a permanent stream nearest Station A.

#### METHOD OF STUDY

Four men, two on the ground and two in the tree (Plate II), spent 50 minutes in the morning and 50 minutes in the afternoon at each station, once a week. These collectors working at ground and tree levels alternated each week to eliminate the factor of personal attractiveness for the mosquitoes. Work began at 8 A. M. at Station A, terminating at 15:50 o'clock in the afternoon at Station D. Ten-minute intervals were allowed for change of station and to make temperature and weather records. The same routine was always followed so that Station A was visited at 8 and 12 o'clock, Station B at 9 and 13, Station C at 10 and 14, and Station D at 11 and 15 o'clock. One full day a week was spent in each forest. In case of rain, work was suspended and the hours lost were completed during the same hours on another day later in the week. Thus in each week a total of 106.6 man hours was spent in captures in the four forests. The man hours per calendar

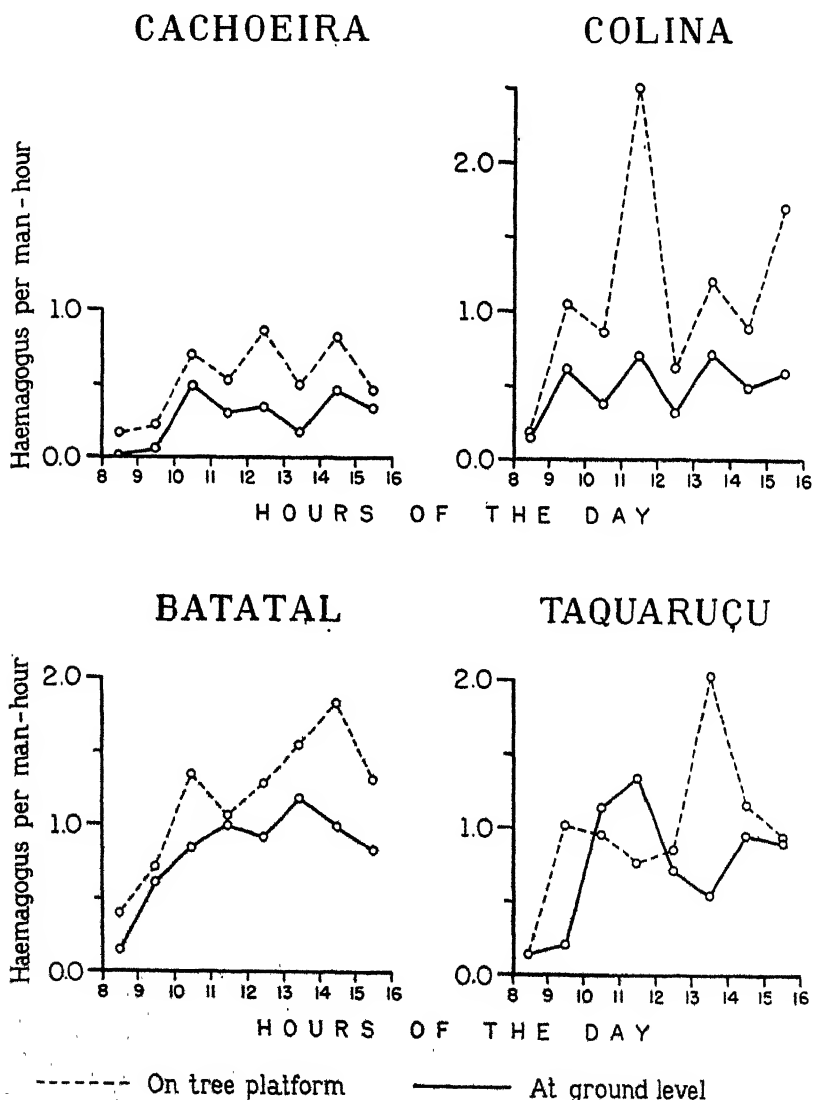
month varied between 213.3 in September, 1945, to 533.3 in July, 1946 and 1947, according to the number of periods spent in each forest.



PLATE II

Mosquito capture stations; tree-platform level and ground level.

All mosquitoes coming to each man were captured by him in small shell vials with a layer of moist cotton at the bottom and closed with a wire gauze stopper. Mosquitoes were taken before they obtained a blood meal from exposed arms, legs and face; a small hand mirror



GRAPH II

*H. spegazzinii* captures per man hour each hour on tree platforms and at ground level in the four forests studied.

was used to facilitate captures from the face. The captures at each station were labelled to indicate the hour and level at which taken. Identification was made in the laboratory the following day, and at the end of the week all live specimens were inoculated into susceptible marmosets for the isolation of yellow fever virus if present. Although yellow fever virus was not encountered, several other strains of filtrable viruses were isolated.

#### TOTAL MOSQUITOES CAPTURED

During the period of study, consisting of 120 weeks covering 28 months from September 19, 1945, through December, 1947, a total of 73,321 mosquitoes was captured and identified. Table I is a summary of these captures showing species and numbers collected during each calendar year and for the entire period, and per cent obtained at tree-platform levels.

The majority of the mosquitoes was captured at ground level; only 13,215, or 18 per cent, being taken on tree platforms. Of those captured on tree platforms almost half belonged to the genus *Haemagogus*. Of the 9,788 *Haemagogus* captured, 6,086 or 62.2 per cent were taken on tree platforms.

#### GENERA AND SPECIES OF MOSQUITOES ENCOUNTERED

Mosquitoes representing 13 genera were captured during the 120 weeks of investigation (Table I). In several genera mosquitoes were identified to species, in others the similarity of adult females made species identification impractical. The genus *Haemagogus* in the region of Passos is represented only by the species *spgazzinii*, as shown by dissections of male genitalia from specimens bred out in the laboratory and a few wild-caught males. Numerous searches were made to locate *Haemagogus* breeding places but very few were discovered. Cut sections of bamboo suspended at various heights ranging from ground to tree-top level failed to attract ovipositing females. It is suspected that oviposition usually takes place in very small tree holes which cannot be located easily. In fact most of the natural breeding places found were of this type. This might explain why *Haemagogus* disappears during prolonged dry spells, while tree-hole breeders which oviposit in larger cavities containing more abundant supply of water are able to continue to emerge long after the rains have ceased.

Of the 13 genera encountered in these routine catches, 3 were represented by very small numbers. These were *Trichoprosopon* with 5 specimens, *Phoniomyia* with 15, and *Uranotaenia* with a single specimen. Certain species were also rarely or infrequently encountered.

The genera and species most commonly collected in all forests were *Psorophora ferox*, constituting 29 per cent of all mosquitoes captured; *Sabethes* sp., representing 14 per cent of the mosquito captures; *Haemagogus spegazzinii*, 13.3 per cent; *Wyeomyia* sp., 10.8 per cent; *Aedes serratus*, 9.3 per cent; and *Aedes leucocelaenus* and *scapularis*, each 4.8 per cent of all captures. A larger proportion of *H. spegazzinii*, *A. leucocelaenus* and *Sabethes* sp., in comparison with the total of each group caught, than of any of the other groups were found at tree-platform level. These were all tree-hole breeders.



## CAPTURE RATES BY MONTHS

Mosquito captures were commenced at Passos at the beginning of the rainy season in September, 1945, and were continued without interruption through 1947. This period included two complete cycles of wet and

TABLE I

GENERA AND SPECIES OF MOSQUITOES CAPTURED, BY YEARS, AND  
NUMBER AND PER CENT CAPTURED AT TREE LEVEL

SPECIES AND GENERA	MOSQUITOES CAPTURED					
	1945 Sept.-Dec.	1946 Jan.-Dec.	1947 Jan.-Dec.	Total 1945-1947	On tree platform	Per cent on tree platform
<b>TREE-HOLE BREEDERS</b>						
<i>Trichoprosopon</i> .....	0	3	2	5	1	20.0
<i>Phoniomyia</i> .....	4	8	3	15	0	0.0
<i>Wyeomyia</i> .....	1,541	3,712	2,630	7,883	889	11.3
<i>Limatus</i> .....	108	722	315	1,145	30	2.6
<i>Sabethes</i> .....	1,636	5,201	3,342	10,269	3,640	35.4
<i>Aedes leucocelaenus</i> .....	534	1,573	1,432	3,539	854	24.1
" <i>terrens</i> .....	299	992	634	1,925	44	2.3
" <i>fulvithorax</i> .....	13	157	216	386	14	3.6
" <i>septemstriatus</i> .....	1	0	0	1	0	0.0
<i>Haemagogus spegazzinii</i> .....	1,848	5,324	2,616	9,788	6,086	62.2
<b>GROUND POOL BREEDERS</b>						
<i>Aedes scapularis</i> .....	1,292	616	1,648	3,556	61	1.7
" <i>fluviatilis</i> .....	0	7	25	32	1	3.1
" <i>fulvus</i> .....	0	10	5	15	0	0.0
" <i>crinifer</i> .....	28	23	44	95	0	0.0
" <i>serratus</i> .....	687	1,415	4,685	6,787	80	1.2
<i>Psorophora albigipes</i> .....	35	346	719	1,100	109	9.9
" <i>ferox</i> .....	4,072	6,890	10,318	21,280	1,276	6.0
" <i>discrucians</i> .....	0	0	1	1	0	0.0
" <i>lutzii</i> .....	2	23	31	56	2	3.6
" <i>varipes</i> .....	3	5	60	68	10	14.7
<i>Taeniorhynchus wilsoni</i> .....	25	51	38	114	8	7.0
" <i>albicosta</i> .....	15	134	150	299	2	0.7
" <i>chrysonotum</i> .....	161	1,341	1,578	3,080	20	0.6
" <i>fasciolatus</i> .....	88	408	515	1,011	5	0.5
" <i>justamansonia</i> .....	0	0	4	4	0	0.0
<i>Culex</i> .....	14	64	146	224	14	6.3
<i>Uranotaenia</i> .....	0	1	0	1	0	0.0
<i>Chagasia fajardoi</i> .....	68	128	175	371	63	17.0
<i>Anopheles</i> sp.....	59	84	128	271	6	2.2
<b>TOTALS</b>						
Tree-hole breeders.....	5,984	17,782	11,190	34,656	11,558	33.1
Ground-pool breeders.....	6,549	11,546	20,270	38,365	1,667	4.3
All mosquitoes.....	12,533	29,328	31,460	73,321	13,215	18.0

dry season and about half of a third rainy season. The wet season may be assumed to begin in October and end in March, followed by six relatively dry months from April to September.

Graph I shows the capture rate, by months, for *Haemagogus* and the tree-hole and ground-pool breeding species of mosquitoes caught at

Passos. The monthly records for rainfall, maximum and minimum temperature and sunlight are presented in the same graph.

It may be seen that there is a rough correlation between the mosquito captures and the rainfall during the preceding month, although this relation is less apparent than when the data are analyzed on a weekly basis. When these studies were initiated, at the beginning of the rainy season of 1945-46, the capture rates per man hour were 4.1 for tree-hole breeding mosquitoes, 1.1 for ground-pool breeders, and 0.3 for *Haemagogus*. The heaviest rains occurred during December, and following these, in January, 1946, the capture rate reached its maximum of 10.9 per man hour for tree-hole breeders and 6.2 for ground-pool breeders. For *Haemagogus* the maximum monthly rate was 5.0 per man hour, also attained in January, 1946. Thereafter there was a gradual decline, both in total mosquitoes and in *Haemagogus*. The lowest point was reached during June when the capture rate fell to 0.1 per man hour in each group, and zero rate for *Haemagogus*.

In the month of October, 1946, following the rains which initiated the second wet season, captures of mosquitoes, including *Haemagogus*, showed a marked increase similar to that observed during the previous year. The highest rate of capture for *Haemagogus* during this season was 2.1 per man hour in November in contrast to the 5.0 per man hour rate in the previous wet season. There were also high rates of 6.0 and 5.4 per man hour for tree-hole and ground-pool breeding mosquitoes respectively during this month. The rate per man hour for capture of ground-pool breeding mosquitoes reached a second and higher peak of 8.6 in January. The capture rate for *Haemagogus* from December through April remained fairly constant and about half that shown for November. As in the previous dry season the fewest captures were made during the cold period in June and July.

Although the study was terminated before the completion of the third wet season, the results during the first three months of this season indicate a continuation of the decline in *Haemagogus* population observed in the comparison of the two previous wet seasons. This reduction took place in spite of apparent adequate rainfall. Such results might be interpreted to mean that there is a periodic cycle in population of these mosquitoes and that these studies were undertaken at a point on the downward trend of the cycle.

Even during the best season, the rates of capture for *Haemagogus* in the Passos area are small in comparison with the rates recorded in equatorial rain forests, as in Colombia, for instance, where daily rates as high as 140 per man hour are recorded by Bates (3). In the Passos studies the highest daily capture rate for *Haemagogus* was 11 per man hour on January 3, 1946. On this same day, the highest rate for any 50 minute period for any one level was attained when 39 *Haemagogus* were taken at 15 o'clock on the 13 meter tree platform at Station D in Batatal. There had been a light shower the previous hour. The highest ground level rate was 26.5 per man hour in a similar period at 10 o'clock at Station C in Taquaruçu, on January 17, 1946. For any one station, including both ground and platform levels, the highest capture rate for a 50 minute period recorded for *Haemagogus* was 24.6 per man hour at 14 o'clock at Station C in Batatal on January 9, 1946.

## SEASONAL VARIATION

The most important vectors of sylvan yellow fever in Brazil have been found to be *Haemagogus spegazzinii*, *Haemagogus capricornii* and *Aedes leucocelaenus*. In the Passos area *H. capricornii* does not exist, and specimens of *H. spegazzinii* and *A. leucocelaenus* become rare during the dry season, especially during the cooler months of June and July. It was of interest therefore to determine the prevalence of other species

TABLE II  
MOSQUITOES CAPTURED, BY MONTHS AND BY YEARS  
1945 - 1947

		SEASON											
		Wet			Dry						Wet		
		Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
<i>Sabethes</i>	1945	.....	.....	.....	.....	.....	.....	.....	.....	275	460	307	594
	1946	1,444	704	260	123	62	13	104	190	447	658	573	713
	1947	759	521	181	85	62	13	28	126	440	361	252	514
<i>Haemagogus spegazzinii</i>	1945	..	.....	.....	.....	.....	.....	.....	.....	57	189	666	936
	1946	2,682	456	327	264	58	2	2	4	0	100	899	530
	1947	583	421	403	400	12	3	0	2	34	271	233	254
<i>Aedes leucocelaenus</i>	1945	..	.....	.....	.....	.....	.....	.....	.....	40	62	216	216
	1946	419	83	87	63	15	2	6	15	3	197	537	146
	1947	291	100	215	128	13	4	2	14	162	180	192	131
<i>Aedes scapularis</i>	1945	.....	.....	.....	.....	.....	.....	.....	.....	5	79	647	561
	1946	31	5	2	16	4	18	80	26	6	287	85	76
	1947	194	477	123	94	56	36	89	93	180	23	137	146
<i>Aedes serratus</i>	1945	.....	.....	.....	.....	.....	.....	.....	.....	27	24	195	441
	1946	313	151	134	164	83	13	7	1	0	72	297	180
	1947	615	448	299	813	242	56	15	1	367	170	883	776
<i>Psorophora ferox</i>	1945	.....	.....	.....	.....	.....	.....	.....	.....	124	269	1,853	1,826
	1946	2,538	615	285	522	64	2	0	3	0	492	1,484	876
	1947	2,779	2,088	1,459	1,108	108	8	8	1	431	377	1,144	807
<i>Wyeomyia</i>	1945	.....	.....	.....	.....	.....	.....	.....	.....	474	604	173	45
	1946	732	380	241	91	29	12	22	119	544	778	306	458
	1947	558	332	198	61	28	16	24	60	497	261	209	386

during this time. Table II is a summary of the monthly catches of the most common mosquitoes in the study forests. Of the seven species and genera listed, *Sabethes* (principally *purpureus*) and *Aedes scapularis* occur in relatively greater numbers during June and July, when *H. spegazzinii* and *A. leucocelaenus* are rare. *A. scapularis* is recognized as a potential vector, and experiments now in progress should indicate whether or not *S. purpureus* is capable of maintaining virus during the dry cold months when *H. spegazzinii* and *A. leucocelaenus* are normally absent or present in very small numbers.

## HOURLY VARIATIONS IN CAPTURE RATES

The first hour's capture from eight to nine in the morning yielded the fewest mosquitoes throughout the period of observation. The highest total catch was made at 13 o'clock. The hourly captures for *Haemagogus* differ from those of other mosquitoes by showing a high catch also at 11 o'clock, followed by a fall at noon and a subsequent rise and fall. The rates per man hour for *Haemagogus* and mosquitoes of all other genera captured during each hour of the day are shown in Table III.

The hourly rates for *Haemagogus* in the combined forests, however, do not represent the picture in the individual forests, as may be seen in Graph II. The hour at which the largest captures were made in trees differed in each forest, occurring at 11 in Colina, 12 in Cachoeira, 13 in Taquaruçu and 14 o'clock in Batatal. The hourly captures at Cachoeira at both ground and tree-platform levels show the least variation in numbers and the least deviation between the two levels. At Batatal also the ground- and tree-level captures roughly parallel each other. The greatest divergence between levels was at Colina where tree captures at 11 o'clock greatly exceeded those at all other hours, while ground captures showed little variation. Here there was a marked drop in the midday tree-level captures and a small drop in the ground-level catches. The hourly captures at Taquaruçu differed from those in other forests by showing opposite trends in the results of ground- and tree-platform-level catches. For instance, at 13 o'clock when there was a fall in the ground-level captures there was a marked rise in tree captures. At 11 o'clock a fall in the tree captures was compensated by a decided rise in ground captures.

## VERTICAL DISTRIBUTION

The total mosquito captures at ground level exceeded those at tree-platform levels for each hourly period. However, in the case of *Haemagogus* the tree-platform-level catches exceeded the ground-level catches at all hours. The per cent of *H. spegazzinii* and of all other species combined caught at tree-platform level at each hour is shown in Table III. It will be noted that there is a reduction in the percentage of *Haemagogus* caught in trees during the midday hours when the sun's rays are directly overhead. There is also a reduction in the case of other species combined, but it is of much smaller range and shorter duration.

For a comparison of the vertical distribution at different seasons, the captures during 10 weeks in each of the two complete wet seasons studied were compared with 10 weeks in each of the two dry seasons at comparable periods in the calendar year. In the two wet seasons there were 5,469 *H. spegazzinii* captured of which 3,431 or 62.7 per cent were taken at tree-platform levels. The combined captures during the dry seasons of 656 *H. spegazzinii* showed 447 or 68.1 per cent captured at tree-platform levels. When analyzed by individual forests, Cachoeira showed the greatest seasonal difference, giving 61.3 and 60.2 per cent in trees in the wet seasons and 90 and 74.6 per cent in the dry seasons. When analyzed by years the differences between tree- and ground-level-capture rates appear to be greater in the year 1946, when the dry season period averaged slightly colder than in 1947 (10° C. as against 12.6° C.).

Bates (3) reports that ground level catches for *H. capricornii*<sup>2</sup> are greater during the dry season. The Passos studies, however, indicate that *H. spegazzinii* shows a preference for higher altitudes in the forest during the dry season, which in this area is also the cold season. This may be due to the slightly higher temperature at the higher elevations.

TABLE III  
MOSQUITO CAPTURES PER MAN HOUR, BY HOURS, AT GROUND AND  
TREE-PLATFORM LEVELS  
1945-1947 (120 weeks)

Hour	<i>Haemagogus</i>				OTHER MOSQUITOES			
	Number per man hour				Number per man hour			
	Ground	Tree	Total	Per Cent in Tree	Ground	Tree	Total	Per Cent in Tree
8	0.1	0.2	0.3	66.2	4.4	0.4	4.8	7.8
9	0.4	0.8	1.2	67.8	7.1	0.8	7.9	10.2
10	0.7	0.9	1.6	56.5	6.7	0.8	7.5	10.9
11	0.8	1.2	2.0	59.2	7.9	1.1	9.0	12.0
12	0.6	0.9	1.5	61.1	10.1	1.2	11.3	10.0
13	0.7	1.3	2.0	66.6	11.9	1.5	13.4	11.6
14	0.7	1.2	1.9	62.0	10.9	1.5	12.4	12.4
15	0.7	1.1	1.8	62.5	11.0	1.5	13.5	12.6

#### SUMMARY

Observations on diurnal mosquitoes in residual forests in the region of Passos, Minas Gerais, were undertaken as a part of a study of a region that had been invaded by jungle yellow fever 10 years previously. Specimens were collected on human bait at ground and tree-platform levels at four stations in four different forests, during four days a week over a continuous period of 120 weeks. Hourly, weekly, monthly and seasonal records were made. Parallel meteorological data was assembled. A total of 73,321 mosquitoes, including 9,788 *Haemagogus spegazzinii*, were taken. The highest monthly rate per man hour was 17.1 for all mosquitoes and 5.0 for *H. spegazzinii* in January, 1946. *H. spegazzinii* and other tree-hole breeders were fewer in number during the second rainy season, and showed evidence of being still further reduced during the first half of the third wet season, when this study was terminated. This may indicate that there exists a cycle of several years' duration in the *Haemagogus* population in addition to the usual seasonal cycle, and that these studies were undertaken on the low side of this large cycle.

<sup>2</sup>The species in Colombia designated as *H. capricornii* by Bates is now recognized as *H. spegazzinii* *fulco*.

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# NUTRITION OF THE EUROPEAN CORN BORER, *PYRAUSTA NUBIALIS* (HBN.)

## I. DEVELOPMENT OF A SATISFACTORY PURIFIED DIET FOR LARVAL GROWTH<sup>1</sup>

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Although rapid advances have been made in the study of insect nutrition during the past decade, the nutritional requirements of the great variety of insects which feed on living plant material has received little attention. The paucity of reports on attempts to rear phytophagous insects on either purified or synthetic diets may be due in part to the difficulties encountered in (1) maintaining reasonably aseptic culture conditions and (2) devising a medium which possesses a texture acceptable to an organism normally feeding on living plant parts.

Because of the recent review of insect nutrition by Trager (1947), there is no need here to discuss the large volume of literature that has accumulated on this subject. It should be pointed out, however, that a start was made in studying the nutrition of the phytophagous insects by Bottger (1942), who conducted a preliminary investigation of the nutritional requirements of the European corn borer.

The present work was carried out as part of an investigation of the relationships between the European corn borer and its host plant. A method of culturing the larvae on a purified diet was desired in order to pursue further certain aspects of the basic problem

### METHODS

The newly-hatched larvae employed in this investigation were obtained throughout the year by the following procedure. A supply of field collected mature larvae was kept in a refrigerated room (40° F.). by transferring the larvae from the cold room to an incubator (85° F.), pupae and the resulting moths were obtained. The moths readily oviposited on the waxed paper covering the top of a wire screen cage in which they were confined. Eggs were incubated in excess of the number of larvae actually needed, in order to insure adequate numbers of normal larvae. Only those larvae that crawled up the sides of the incubating dish to the cover were used. This procedure helped to prevent the use of weak or abnormal individuals. The larvae were placed on nutritive media within eight hours after hatching.

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The larvae were reared in shell vials of about 25 milliliters capacity. The vials were plugged with cotton and autoclaved before the medium and larvae were placed in them. The sterile medium was smeared on the side of the vial near the bottom with a small sterile spatula. One larva was placed in each vial. This isolation was necessary because of cannibalism, particularly on deficient diets. Twenty larvae were started on each diet, and all larvae were transferred to fresh media in clean vials every third day. The rearing vials were placed in an incubator which maintained a temperature of approximately 85° F., which is within the range considered favorable to the development of this insect. The temperature was subject to appreciable variation ( $\pm 5^\circ$ ), but since a control culture was always run simultaneously with the experimental cultures, the effects of temperature variations were not disturbing to the results obtained.

The conditions under which the rearing was carried out were not completely aseptic. The diets and the vials were autoclaved, but the larvae were not treated to prevent the introduction of micro-organisms on their surfaces. The necessity of removing the larvae for weighing and transferring to fresh vials also made it difficult to maintain aseptic conditions. However, an inhibitor of molds and bacteria was included in each diet, and vials showing contamination were removed from the experiment. The practice of transferring the larvae to fresh media every third day minimized the influence of any undetected contamination.

The nutritive material was suspended in an inert carrier of aqueous agar-agar and fibrous cellulose (cellu-cotton), which was essentially the same as that developed by Bottger (1942). The procedure used in preparing the diets was as follows. The agar and one-half of the water was placed in an Erlenmeyer flask in a boiling water bath. After the flask had stood for a few minutes, the other ingredients were introduced, followed by the remainder of the water. The mixture was stirred for about fifteen minutes with a motor-driven stirrer. The flask was removed from the water bath, plugged with cotton, and autoclaved at fifteen pounds for twenty minutes. After being removed from the autoclave and allowed to cool somewhat, it was stirred by shaking for a few minutes. The finished diet was a stiff, homogeneous paste. The flasks were stored in a refrigerator and were removed only long enough to prepare vials.

The pH of one gram of diet suspended in ten milliliters of distilled water varied from 5.3 to 6.1. Most diets were about pH 5.7. The slight differences in pH did not give detectable differences in the response of the larvae to the diets. The pH range of the diets was similar to the pH range of sap expressed from samples of fresh corn leaves, Beck and Lilly (1949).

The dried corn leaves incorporated into the diet were prepared by a method of lyophilization. Leaves from corn plants about three feet high were homogenized in a Waring blender within thirty minutes after being collected. The leaf suspension was kept cold during the homogenizing by the addition of crushed ice. The homogenized sample was transferred to a round-bottom flask and frozen at  $-70^\circ\text{C}$ . in a mixture of dry ice and 95% ethyl alcohol. By revolving the flask

within the freezing mixture, the plant material became frozen in an even layer on the sides of the flask. When completely frozen, the flask was attached to a vacuum pump and evacuated continuously until the leaf material was dry. In order to prevent the accumulation of water in the pump, and to help maintain the leaf substance in a frozen state during the drying process, a trap flask immersed in an alcohol and dry ice mixture was placed in the system between the evacuating pump and the flask containing the plant substance. The dried leaf material was transferred to a brown bottle, a small container of desiccant ( $\text{CaCl}_2$ ) was added, and the bottle sealed with paraffin. If these precautions were not taken, the stored lyophilized leaf material accumulated sufficient moisture within a few weeks to allow growth of molds.

The maintenance of adequate controls for the nutrition experiments has posed a difficult problem. Since there was no natural diet available which was well suited for this type of work, the best available purified diet was used as the control in each experiment. When an experimental variation yielded better results than the current control diet, it became the control diet for subsequent experiments. Although this method allowed comparison of the various diets within an experiment, and also allowed a gradual improvement of the basal or control diet, it did not allow direct comparison of the results of one experiment with those of another in which the control diet was different in some respect. All of the experiments reported were carried out at least twice.

It was found that the growth curve and the percentage of the larvae reaching maturity were the best criteria of the suitability of a diet. Larval maturity was considered to be either pupation or diapause. Both the univoltine and multivoltine strains of European corn borer were represented among the larvae used, and as a consequence, some larvae went into diapause instead of pupation. As it was not possible to determine exactly when a state of diapause was reached, data concerning the time required to reach maturity were not sufficiently exact to be of any real significance.

Preliminary to the investigation of the nutritional requirements, it was considered desirable to determine the digestive enzymes present in the larval digestive tract. The methods employed were essentially those of Swingle (1928). A homogenate of fifteen larval digestive tracts was employed in each test. The tissue homogenate was incubated with the substrate in a solution buffered at pH 7.2, which was found to be the approximate pH of the larval mid-gut. The only deviation from the methods given by Swingle was in the tests for proteases. Instead of Swingle's method of using dyed proteins, the end point of which was the passing of the dye from the protein into the solution, we employed a method in which two small strips of hard paper were held together with coagulated egg white. The end point was the separation of the paper strips as a result of the digestion of the binding layer of protein. In addition to Swingle's tests, the presence of galactanase was tested by incubating buffered tissue homogenate with agar-agar, followed by tests for both reducing substances and for osazones. In each test a control of boiled tissue homogenate plus buffer and substrate was run. The results from any series in which the control yielded a positive reaction were discarded.



## EXPERIMENTAL RESULTS

*Digestive Enzymes*

Table I presents the results of the qualitative tests for the various digestive enzymes. These data show that the European corn borer larva has a rather simple array of digestive enzymes, since invertase, trypsin, erepsin, and lipase were the only ones detected. These findings confirm the work of Bottger (1940).

The terms trypsin and erepsin are used advisedly. The term trypsin is used only in the sense of an enzyme, or complex of enzymes, capable of hydrolysing proteins at about pH 7. There is no basis for considering this enzyme identical to the trypsin found in higher animals. Erepsin in higher animals has been shown to be a complex of peptidases,

TABLE I

RESULTS OF QUALITATIVE TESTS FOR DIGESTIVE ENZYMES IN THE INTESTINAL TRACT OF FOURTH AND FIFTH INSTAR LARVAE OF THE EUROPEAN CORN BORER

Enzyme	Substrate	Number positive reactions obtained	Number negative reactions obtained	Total attempts	Conclusion
Invertase.....	Sucrose.....	16	0	16	Present
Maltase.....	Maltose.....	0	8	8	Absent
Lactase.....	Lactose.....	0	12	12	Absent
Amylase.....	Corn starch.....	0	12	12	Absent
Cellulase.....	Cellulose.....	0	12	12	Absent
Galactanase....	Agar-agar.....	0	4	4	Absent
Pepsin.....	Egg albumin (pH 2).....	0	8	8	Absent
Trypsin.....	Egg albumin (pH 7).....	6	2	8	Present
Erepsin.....	Peptone.....	12	0	12	Present
Lipase.....	Olive Oil.....	16	0	16	Present

Baldwin (1947). In the present investigation, no attempt has been made to determine whether such is the case in the European corn borer. The tests used do not allow a distinction between the enzyme referred to as trypsin and the one called erepsin. However, the results indicate that corn borer larvae are able to utilize fats, proteins, and at least the disaccharide sucrose in their diet.

*Nutrition*

A purified diet allowing apparently optimum growth of the larvae of the European corn borer has been developed. This diet, Table II, allowed growth to maturity (pupation or diapause) with apparently normal adult moths resulting. Usually about 90% of the larvae reached maturity, and this far exceeds normal survival in the field, Stirrett (1938). The fecundity of the resulting moths has not been tested, because only small numbers have been available at any one time.

The requirement for lyophilized leaf material in the diet was discovered only recently. For this reason, in all except the last experiment reported the diet was without leaf material, and contained 14.4% cellucotton instead of 9.4%. In the absence of the lyophilized leaf preparation, growth was inferior and only 20% to 40% of the larvae reached maturity. The issuing moths were small, and, in the case of the females, were crippled and short-lived.

*Inert carrier.*—The function of the agar and the cellu-cotton was that of an inert carrier for the nutritive constituents. Qualitative digestive enzyme tests have failed to demonstrate that the borer larvae can hydrolyze either agar or cellulose (Table I). ✓

TABLE II  
COMPOSITION OF A PURIFIED DIET ALLOWING SATISFACTORY GROWTH AND  
MATURATION OF EUROPEAN CORN BORER LARVAE

Function	Substance	Amt. used (g.)	Per cent of dry diet
Inert carrier	Distilled water.....	100 ml.	0.0
	Bacto Agar.....	3.000	17.3
	Cellu-cotton.....	1.625	9.4
Micro-organism inhibitor	Butoben.....	0.200	1.2
Carbohydrate	Glucose.....	4.900	27.7
Protein	Casein.....	4.380	25.0
Lipids	Cholesterol.....	0.175	1.0
	Corn oil.....	0.175	1.0
Minerals	Wesson's Salts.....	0.350	2.0
Vitamins	Brewer's yeast powder....	1.750	10.0
	Choline chloride.....	0.070	0.4
Unknown factor(s)	Dried corn leaves.....	0.875	5.0
		17.500 g.	100.0%

*Micro-organism inhibitor.*—Because it was not possible to maintain aseptic culture conditions, a micro-organism inhibitor was added routinely. In the earlier experiments, "Nipagin M" (methyl parahydroxybenzoate) was used. Because additional supplies of "Nipagin M" were not available, later diets contained "Butoben" (n-butyl parahydroxybenzoate—Merck). In the absence of an inhibitor, the media were quickly attacked by molds. When an inhibitor was employed, an occasional vial became visibly contaminated, but in every case it was discarded. As far as could be determined, the inhibitor was not toxic to the larvae in the amounts used.

*Carbohydrates.*—In some of the earlier experiments, both glucose and sucrose were included in the diet. It was found, however, that the use of such a mixture was unnecessary, and glucose was adopted for

routine use. When the only dietary carbohydrate was corn starch or powdered cellulose, growth was inferior and no larvae reached maturity. Figure 1 illustrates the growth curves obtained.

*Proteins.*—Bottger (1942) reared corn borer larvae to maturity on diets in which casein was the only proteinaceous material, but observed

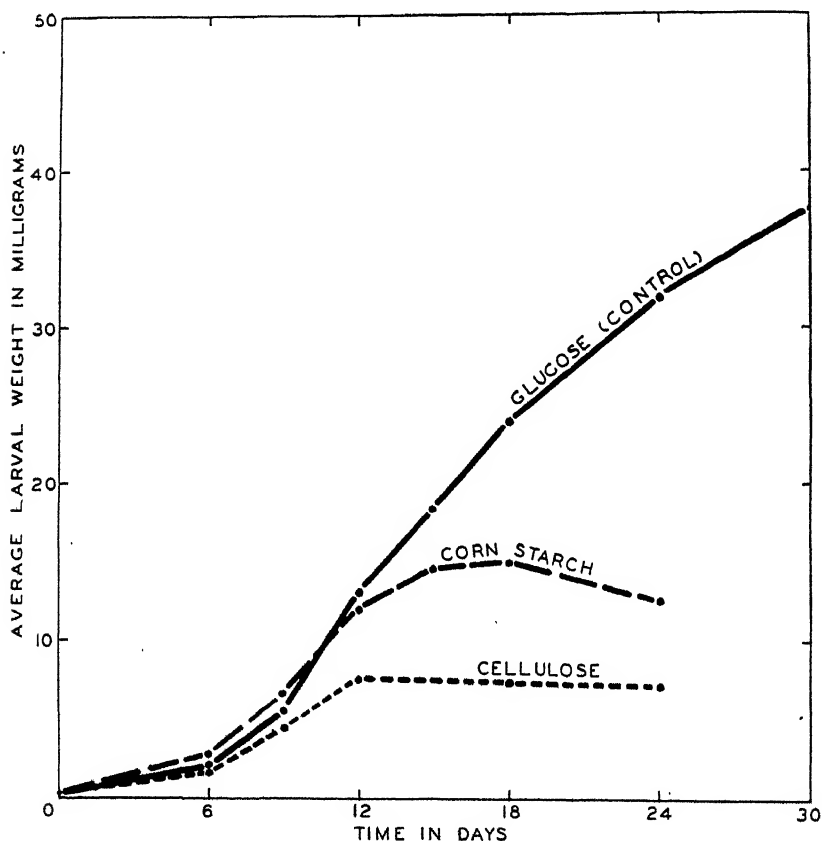


FIG. 1. Growth of European corn borer larvae on diets containing different carbohydrates.

that the inclusion of a peptone preparation was slightly beneficial. In our early experiments, we were unable to obtain growth of larvae on a diet in which casein was the only proteinaceous constituent. Figure 2 presents typical results, and shows that if peptone (Parke, Davis and Company's Bacteriologic Peptone) were included, good growth resulted. In the absence of the peptone no larvae matured, although mortality was not excessive until about thirty days.

A long series of experiments was run in an effort to identify the active factor in peptone. It was felt that the response to peptone might

be due to any one of several possibilities: (1) The possibility of the response being due to a more nearly optimum ratio of amino acids in the peptone-casein mixture was tested by supplementing the casein diet with several amino acids and proteins. L cystine, L tryptophane, L histidine, DL methionine, and glycine were added singly and in

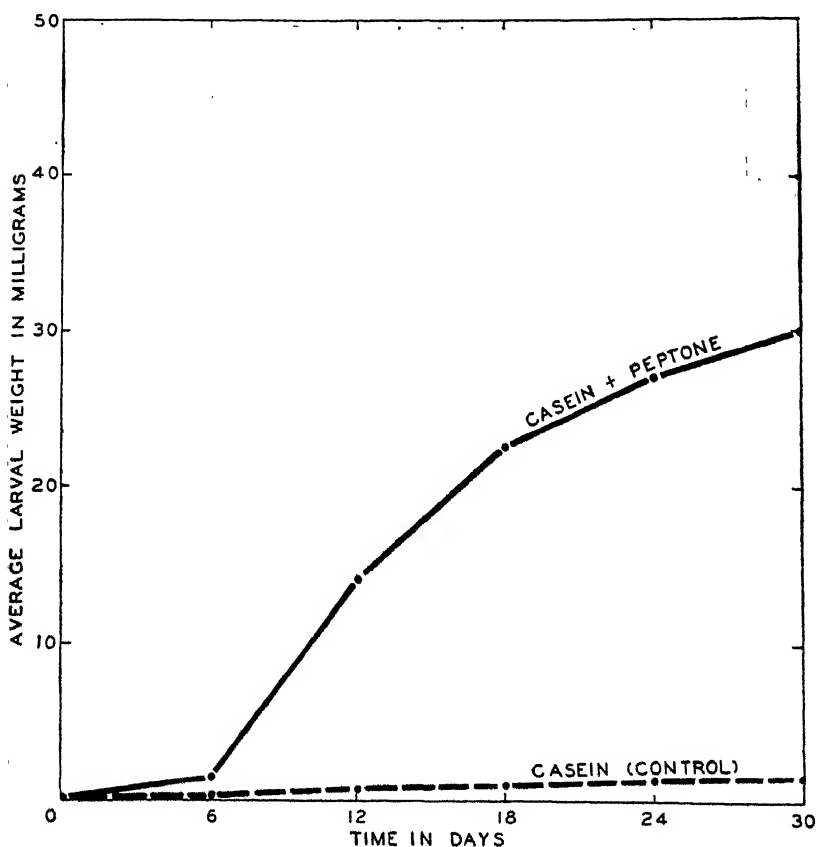


FIG. 2. Growth of European corn borer larvae on diets containing casein supplemented with peptone.

various combinations. No combination tested replaced the peptone. The proteins zein, gluten, fibrin, lactalbumin, and gelatin were also tested singly and in various combinations, but were found to yield no better results than did casein when peptone was omitted. Their dietary suitability in the presence of peptone was not determined. (2) The possibility that the larvae might require fragments of proteins such as peptides or peptones was tested by using hydrolyzed casein instead of whole casein in the diet. Both enzymatic and acid hydrolyzed casein were tested, the latter being supplemented with L tryptophane and L tyrosine. However, growth was not obtained unless peptone

was also included. (3) The possibility that the growth response was due to some factor present in the peptone preparation as an impurity was also considered. In testing this hypothesis, several materials were used. Eventually it was found that either lecithin or choline could replace peptone in the diet. Since the lecithin molecule contains a

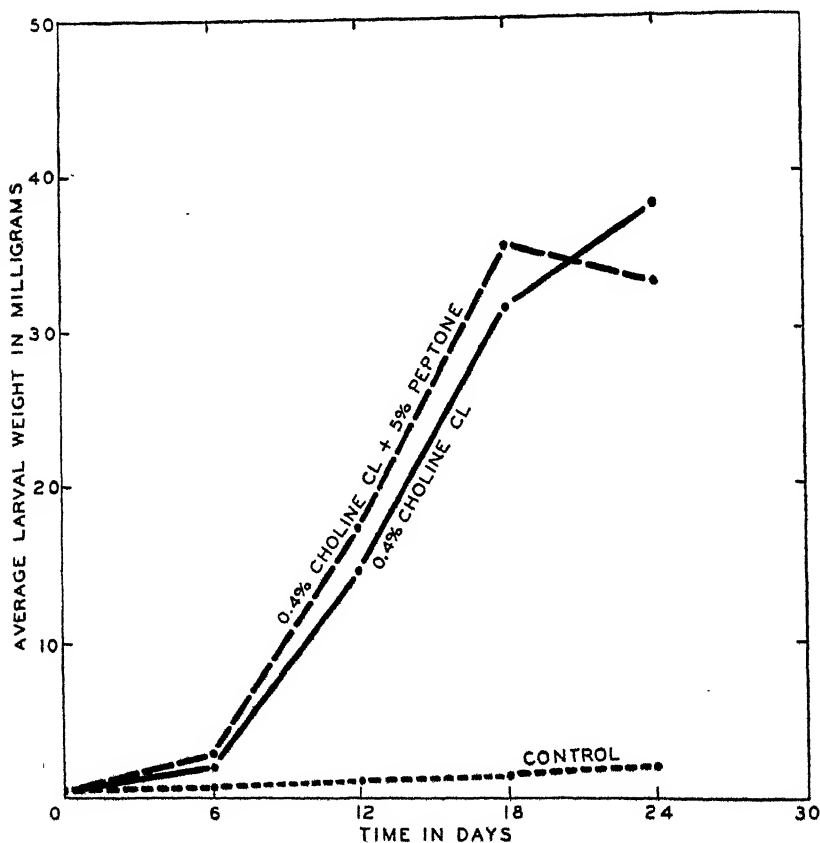


FIG. 3. Growth of European corn borer larvae on diets containing casein supplemented with peptone and choline chloride.

molecule of choline, it was concluded that choline had been the limiting factor in the peptone-free diets. The amount of choline chloride giving the best larval growth was found to be 0.4% of the dry diet. This amount is in addition to that contained in the brewer's yeast powder present in the diet, indicating that this insect has a rather high choline requirement. Figure 3 shows that the addition of peptone to a diet containing choline chloride did not improve the larval growth.

The optimum level of casein in the diet proved to be about 25%, as shown in Figure 4. 20% was inferior to the higher levels; 35% gave

good growth, but the number of larvae reaching maturity was inferior to the number maturing on either 25% or 30%. The 25% level was adopted for routine use. Proteins other than casein have not been tested in the diet of the borer, except under conditions in which the protein employed was not the limiting dietary factor. This was the

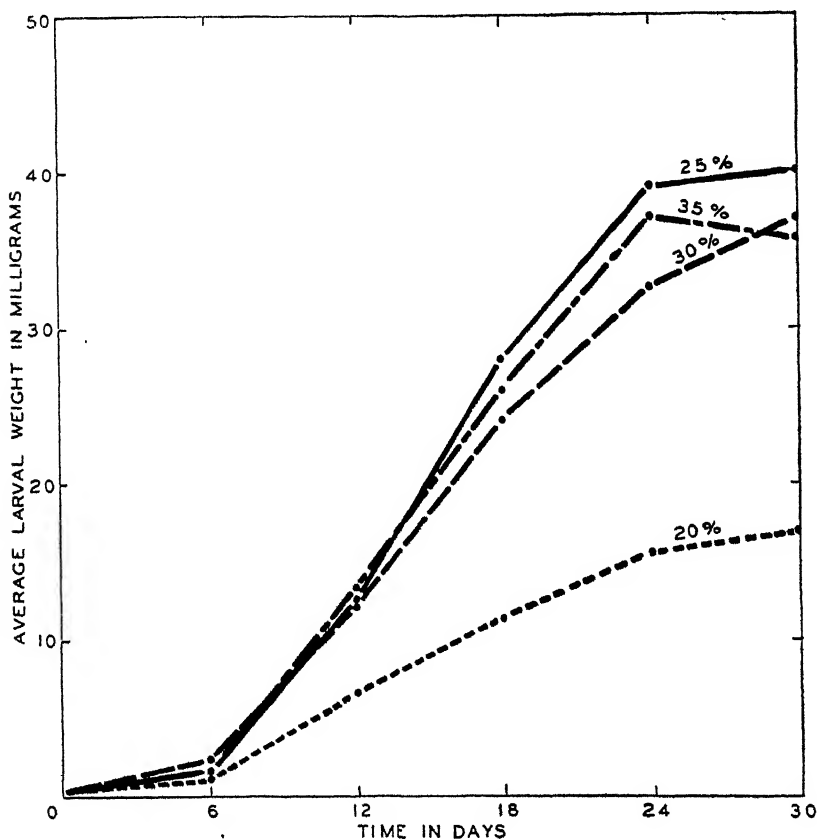


FIG. 4. Growth of European corn borer larvae on diets containing different levels of protein (casein).

situation in some of the experiments leading to the identification of choline as the "peptone factor" referred to above.

*Lipids.*—Virtually all recent studies of insect nutrition have shown that insects require a sterol in their diets. In the investigations thus far reported in the literature, cholesterol has satisfied this requirement without exception. In our earlier experiments no sterol was included in the diet. A plant oil was included, however, under the assumption that it would satisfy the sterol requirement, as well as any other lipid requirement. It was found that corn oil and wheat germ oil were

equally effective. Corn oil was adopted for routine use. The optimum level of oil was found to lie between 2% and 4%. A 3% level was accordingly adopted. It was found subsequently that the amount of oil could be reduced to 1% if cholesterol was added at a 1% level (Figure 5).

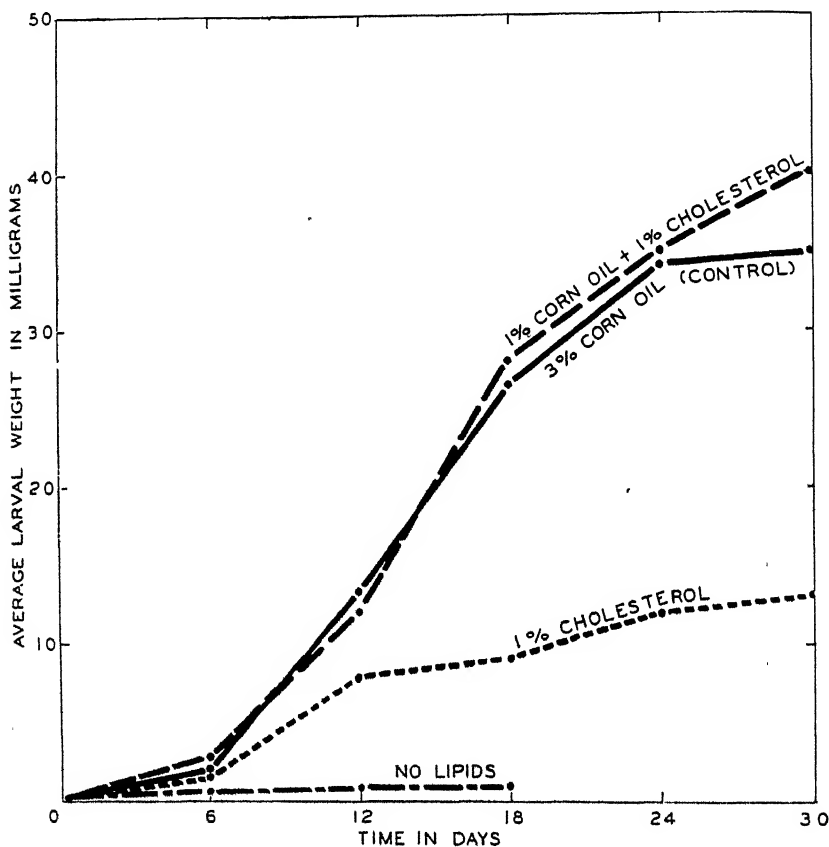


FIG. 5. Growth of European corn borer larvae on diets containing different proportions of corn oil and cholesterol.

As also shown in Figure 5, no growth and no survival beyond about eighteen days were observed if both corn oil and cholesterol were omitted from the diet. Cholesterol alone allowed poor growth and none of the larvae reached maturity. With both corn oil and cholesterol present, good growth was obtained and about 30% of the insects reached maturity. Since 1% cholesterol is in excess of the amount required to satisfy the sterol requirement, these results suggest that one or more factors in corn oil are required besides a sterol. The sterols isolated from corn oil allowed no better growth than did cholesterol.

This problem is being investigated currently, and the results thus far obtained indicate that corn oil in the borer diet may be replaced completely by cholesterol, linoleic acid, and alpha tocopherol, which is similar to the results of Fraenkel and Blewett (1946).

*Minerals.*—The mineral ions required by European corn borer larvae have not yet been investigated. It has been found, however, that several of the salt mixtures commonly used in rat and chick nutrition studies allowed equally good growth. We have used Wesson's salts routinely. When omitted from the diet, growth was poor. When present at levels from 1% to 4%, no appreciable differences in growth were observed. A 2% level was adopted for routine use.

*Vitamins.*—No investigator has yet found an insect requiring any of the vitamins other than those of the B complex. The results of

TABLE III  
MIXTURES OF B VITAMINS USED IN ATTEMPTS TO REPLACE BREWER'S YEAST POWDER  
IN A PURIFIED DIET FOR LARVAE OF THE EUROPEAN CORN BORER

VITAMIN	AMOUNTS USED PER GRAM OF DIET		
	No. 1. ( $\mu$ g.)	No. 2. ( $\mu$ g.)	No. 3. ( $\mu$ g.)
Chlorine chloride.....	1000	2000	500
Thiamine.....	12	24	6
Riboflavin.....	18	36	9
Nicotinic acid.....	100	200	50
Ca pantothenate.....	40	80	20
Pyridoxine.....	16	32	8
Inositol.....	2000	4000	1000
p-Amino benzoic acid.....	50	100	25
Folic acid.....	5	10	2.5
Biotin.....	0.6	1.2	0.3

Fraenkel and Blewett (1946) indicate that larvae of the lepidopterous genus *Ephesia* may require vitamin E, but this point has not yet been definitely established.

In the present work, brewer's yeast powder was included in the diet as a source of the B vitamins. As was discussed above, the yeast powder contained insufficient choline, necessitating the inclusion of supplementary choline chloride in the diet. In the absence of yeast powder, or other sources of vitamins, no growth was obtained. Attempts were made to replace the yeast powder with mixtures of the known B vitamins (except B<sub>12</sub>). Table III gives the composition of the vitamin mixtures used. Mixture 1 is essentially the same as one described by Noland *et al.* (1949), who were able to use it instead of yeast powder in the diet of the German cockroach, *Blatella germanica*. Mixture 2 contains the same vitamins as mixture 1, except that the amount of each vitamin is doubled. Mixture 3 contains one-half the levels of mixture 1. Therefore, mixture 2 contains the vitamins in amounts four times as great as in mixture 3. By using this series, it



was felt that if any one of the vitamins was present in either insufficient or excessive quantities in mixture 1, the growth on the other mixtures would disclose that fact. The choline chloride included in these mixtures is in addition to the 4000 gamma per gram of diet added routinely to the basal diet.

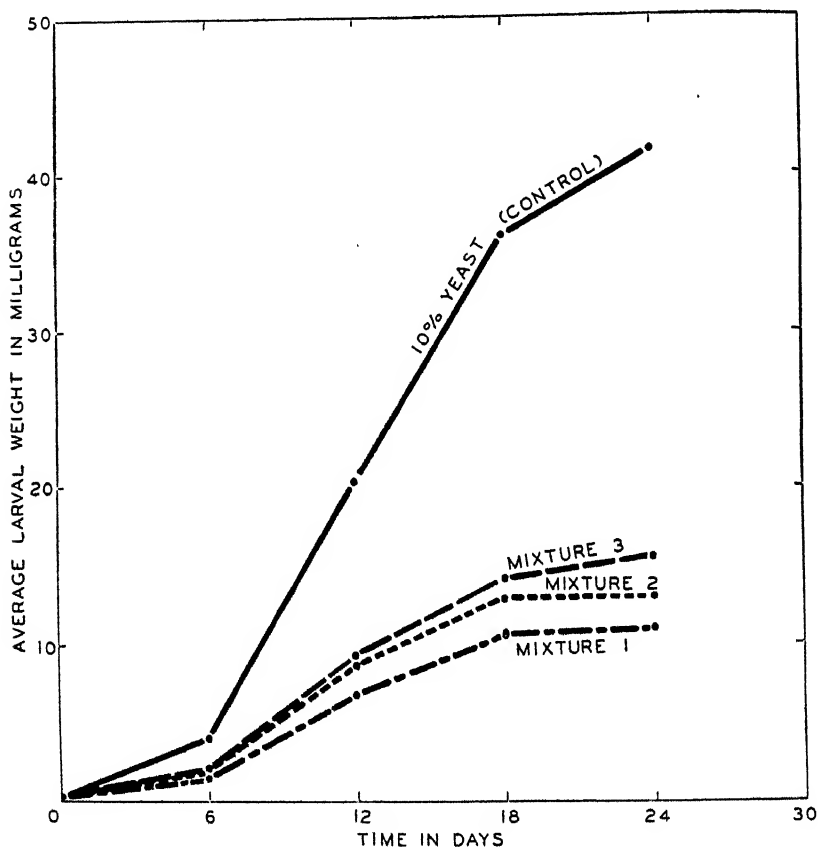


FIG. 6. Growth of European corn borer larvae on diets containing different mixtures of B complex vitamins.

Figure 6 presents the results obtained with diets in which the yeast powder was replaced by one of the vitamin mixtures. Growth was poor in all cases, and none of the larvae reached maturity. Since the growth observed was essentially the same on each of the diets containing the vitamin mixtures, the presence in yeast of one or more required factors not represented in these mixtures is strongly indicated. Recent work of Schultz, *et al.* (1946) with *Drosophila* has indicated the importance of ribose nucleic acid in the diet of that insect. However, ribose nucleic acid added to vitamin mixture 1 did not improve the growth response of the borer larvae.

Bottger (1942) found no need for vitamins in the diet of European corn borer larvae, although he observed that the addition of thiamine and alpha tocopherol was of slight benefit. He included no yeast powder or additional choline in the larval diets, although with respect to the latter factor, he noted that the addition of peptone somewhat

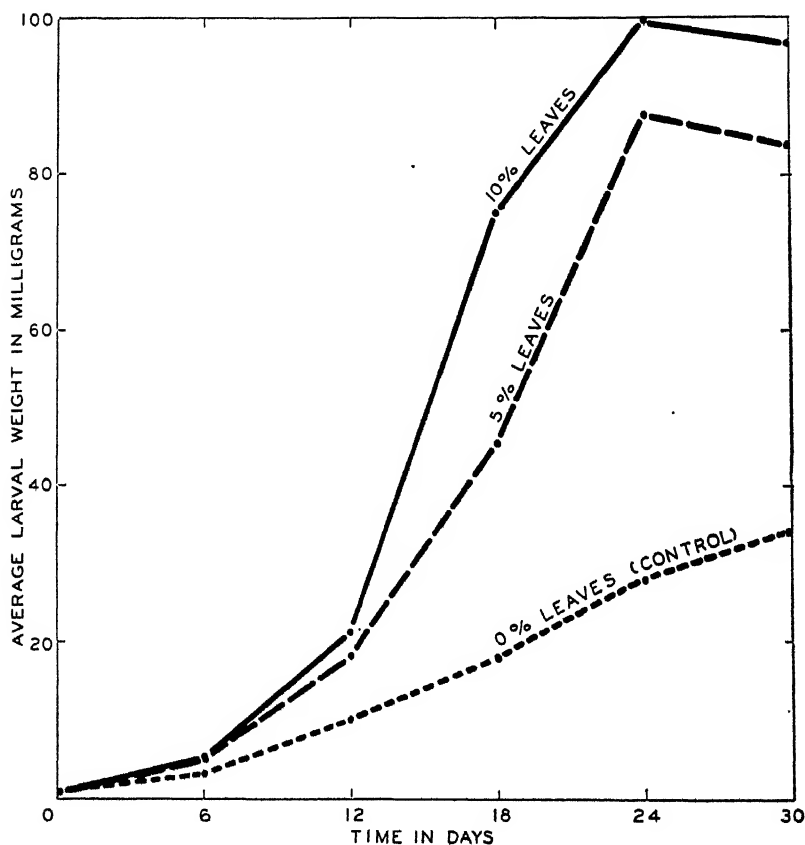


FIG. 7. Growth of European corn borer larvae on diets containing lyophilized corn leaves.

improved the growth response. The great differences between his results and ours can probably be explained on the basis of heavy contamination of his cultures, as an examination of his published methods shows that no precautions were taken against contamination by micro-organisms.

That there is at least one unknown factor required by the borer is strikingly demonstrated by the addition of lyophilized corn leaves to the diet. The growth response obtained when either 5% or 10% of the diet was replaced by such a leaf preparation is shown in Figure 7. Because the leaf material was largely fiber, the addition was made at

the expense of the cellu-cotton (fibrous cellulose) content of the diet. Growth on such a diet was apparently optimum, the larvae attaining an average weight of from 85 to 100 milligrams in twenty-four days, and from 90 to 100 per cent of them attaining maturity. Although Figure 7 shows the growth to be better on 10% than on 5%, most of the experiments showed little difference between the two levels of leaf material. The identity of this "corn leaf factor" is now being investigated.

#### SUMMARY AND CONCLUSIONS

1. The digestive tracts of larvae of the European corn borer were found to contain a protease, a peptidase, a lipase, and an invertase.
2. A purified diet allowing apparently optimum growth of larvae of the European corn borer has been developed. It consists of glucose, casein, cholesterol, corn oil, Wesson's salts, brewer's yeast powder, choline chloride, and lyophilized corn leaves. The nutrients are suspended in an inert carrier consisting of aqueous agar and fibrous cellulose.
3. Mixtures of ten B vitamins failed to replace brewer's yeast powder in the larval diet under the conditions of the experiments.
4. Choline was found to be an essential factor in the larval diet and is required at relatively high levels.
5. A "corn leaf factor" that has not yet been identified is required for optimum growth and is present in lyophilized corn leaves.

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# THE DEVELOPMENT AND BEHAVIOR OF POPULATIONS OF *DIABROTICA 11-PUNCTATA* IN FOOTHILL AREAS OF CALIFORNIA

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The western spotted cucumber beetle, *Diabrotica 11-punctata* Mannerheim, is at times a serious local pest of deciduous stone fruits (Michelbacher *et al.*, 1941, 1943). An attempt is made here to delimit the factors influencing the population fluctuations of this species in relation to infestations in deciduous fruit orchards. The problem of infestations in field and vegetable crops is not comparable to this situation.

## SUMMARY OF BIOLOGY

Certain details of the biology of *D. 11-punctata* have been published by Michelbacher *et al.* (1943) and Rockwood and Chamberlain (1943), and only such information as is required for an interpretation of the present paper is included here. *Diabrotica 11-punctata* penetrate the cracks and crevices of the soil to lay their eggs in the moist situations. Rockwood and Chamberlain (1943) stated that the eggs are probably laid wherever the beetles are feeding, but certain of our laboratory observations would indicate that the soil moisture must be favorable and suitable hosts available for the maximum oviposition rate. The eggs are usually laid in clusters of six or less, but occasionally fifty or more will be laid in one spot. There are three larval instars and under the conditions that prevail in the spring, approximately 60 days are necessary to complete the larval development.

The western spotted cucumber beetle normally passes the winter in the adult stage, although it is possible that all stages may be found during the winter in the most southern parts of its range. The species has no true diapause but becomes dormant during the winter as a result of lowered temperatures. However, in the intermediate parts of its range, it may become active on favorable winter days. The beetles that make up the overwintering brood come largely from the last summer generation. However, beetles from earlier broods may also be involved since a small part of the spring brood may live until fall. As the temperatures increase in the spring the adults emerge from their winter quarters. They become active at about 50° F., but do not fly to any extent until the temperature reaches 60° F. The time of spring emergence from winter quarters varies from January to March depending, of course, on the prevailing weather. The adult beetles, as they come forth from winter quarters, feed on any succulent plants available. Oviposition begins immediately and continues through April, or as long as the overwintering adults remain alive. This oviposition results in the spring brood of larvae. In the San Joaquin Valley, a summer brood reaches its maximum size sometime in August and in orchards is usually much smaller than the spring brood. The fall

brood reaches its maximum size in October. Both the summer and fall broods are primarily restricted to the irrigated valleys and do not appear in the dry uncultivated areas. A portion of the fall brood returns to the hill area in late fall to overwinter. It is believed that it is the main source of the spring brood.

#### THE ORIGIN OF ORCHARD INFESTATIONS

Infestations of deciduous fruit orchards by adults of *Diabrotica 11-punctata* occur in all parts of California. However, the areas where these infestations reach an economic level are very limited and usually occur only in the orchards adjacent to the foothills. The distribution in the San Joaquin Valley is more or less typical of the state. The main fruit areas are scattered through the central portion of the valley and in general are never seriously attacked by *Diabrotica*. But where there are orchards at or near the margins of the hills, invasion from the hills may be expected in years favorable for large *Diabrotica* populations.

The pattern of infestation, the suddenness of the appearance in orchards, and the paucity of suitable breeding grounds in the orchard area indicate that only a small part of the population originates in the orchard area. This is well demonstrated, for example, in the Brentwood fruit district of Central California, where most of the observations reported in this paper were made. This district is situated on the eastern plain of Contra Costa County in the extreme northwest portion of the San Joaquin Valley. The western edge of the district borders the foothills. In this region orchard surveys of *Diabrotica* population trends have been made over a period of years by Michelbacher *et al.* (1941, 1943). The most intensive studies were conducted during the 1940 and 1941 seasons. The maximum populations encountered in different orchards are presented graphically in figure 1. This figure illustrates how the orchards with the highest infestations are confined to the fringe close to the uncultivated region. Cultivation and other cultural practices do not allow the beetles to complete their development in the spring except possibly in small areas near the trunks of the trees, along fence rows, and in other weedy areas. These small areas are not large enough to account for the size of the populations that develop in some years. If such breeding sites were the main source of the spring brood, the infestation would be more evenly distributed over the district and would not be concentrated near the hills. Another indication of an outside origin is the small percentage of the beetles which are teneral at the time of their sudden appearance in the orchards.

The breeding area of the spring brood in the uncultivated area to the west of the Brentwood fruit area consists of rolling hills and a few steep slopes with shallow intervening valleys. The valleys and ridges have a general easterly trend and are largely covered by annual vegetation. They are mainly used as pasture for cattle and sheep, with some of the lower hills being used for the production of wild hay and grain. Mount Diablo and other high ridges to the west produce a rain shadow, the normal seasonal rainfall varying from about 23 inches at the summit of Mount Diablo to about 11 inches at Brentwood. Practically all the precipitation occurs in the cooler months. The normal rainfall for the period from April to October, inclusive, is less

than an inch. This distribution of rainfall results in moist green conditions in the winter and spring followed by complete desiccation of the annual vegetation in the dry summer. The area is well-drained by numerous intermittent streams. The climate is mild, with warm

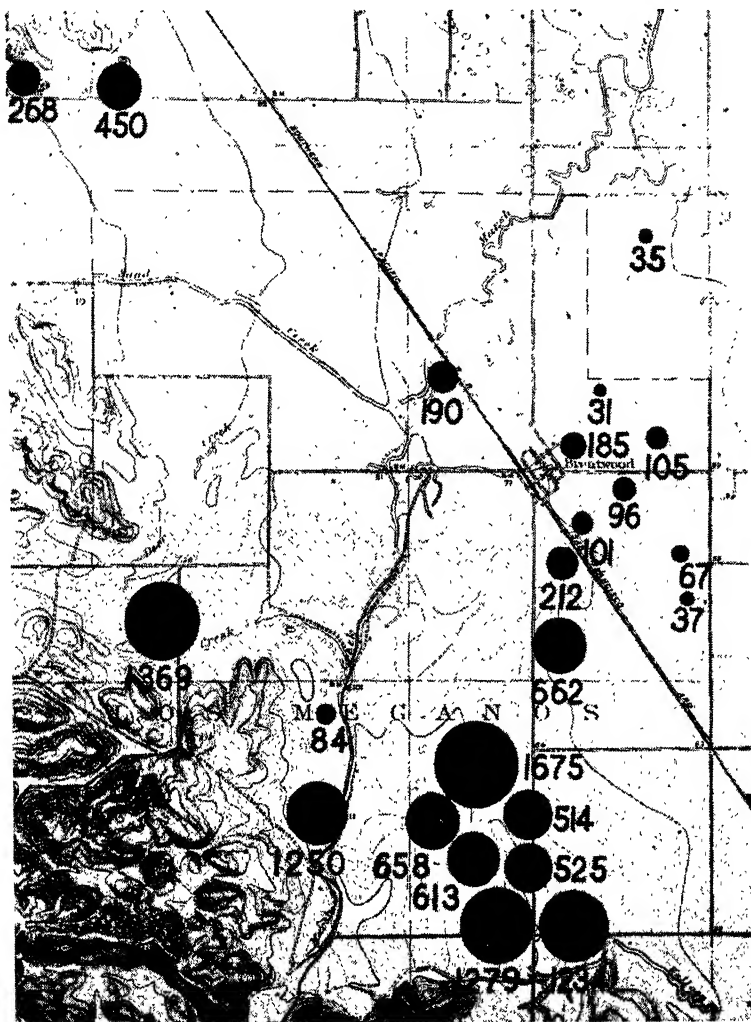


FIG. 1. Maximum diabrotica population found per tree in different orchards in the Brentwood area, 1941. The figure shown with the dots represents the average number of beetles per tree.

dry summers and cool moist winters of the Mediterranean type. The summer fogs of the coast do not reach this area. In the drier sections the hills are typically bald and clothed with a grassland formation on both the north and south slopes. As the elevation increases toward

the west, occasional specimens of the coast live oak (*Quercus agrifolia* Neé) occur first on the north slopes and then on the south slopes. There is a transition from grassland to savannah to woodland. A riparian element of sycamores, willows, and alders occurs along portions of the larger streams.



FIG. 2. Uncultivated area to west of Brentwood. A portion of Long Valley shows in upper left corner, Deer Valley is in the center, and Horse Valley shows at the bottom.

The transition from grassland to woodland is illustrated in figure 2. From Horse Valley at the bottom of the map to Long Valley at the top there is a gradual increase in elevation and rainfall. The ridges run from northwest to southeast and the south slopes are covered by grassland. The north slopes are covered with oaks and the denseness of the stand increases with elevation and rainfall.

SIZE AND DEVELOPMENT OF SPRING POPULATIONS IN THE  
UNCULTIVATED AREA

The most important factors which favor a large spring emergence are (1) a large overwintering brood, (2) a large area of rolling, bald grassy hills and their intervening valleys for breeding sites, and (3) adequate rainfall and other favorable weather conditions to maintain proper soil moisture in the breeding sites until the *diabrotica* complete their development.



FIG. 3. Excellent breeding spot with scattered oak trees on a sandy grassy ridge about two and a half miles west of Byron.

The original size of the spring brood (i.e., the number of eggs laid in the spring) is dependent upon the size of the brood emerging from winter quarters. This effect was demonstrated in the difference in orchard populations in 1940 and 1941. These two years had very similar weather conditions. However, 1940 resulted in orchard populations only as high as 776 per tree, while in 1941 the orchard populations reached 1675 per tree. These differences can probably be explained by the small population carried over from 1939 into the winter of 1940 as compared to the relatively large populations which carried over into 1941. The differences in the size of the overwintering brood is largely dependent on the size of the fall brood. Parasites and predators seem to be of little importance in California. However, Rockwood and Chamberlain (1943) working in Oregon have observed that as high as 32 per cent of the overwintering brood may be parasitized by the dipterous parasite, *Celatoria diabroticae* (Shimer) and 60 per cent by an unknown mermithid.



From analysis of the conditions in the Brentwood district as well as other areas of California, it would seem that the type of breeding site is very important in determining the emergence of the hill spring brood. The rolling, bald, grassy hills (fig. 3) seem to be ideal. *Diabrotica 11-punctata* will also develop on the roots of grasses and legumes in wooded areas but because of the lower soil temperatures in these areas the beetles do not emerge as soon as those in grassland. In certain high situations on Mt. Diablo the beetles remain in wooded canyons or along stream bottoms throughout the summer without migrating out to the valley.

In the grass-covered hills, the most critical factor for the developing larvae is soil moisture. The ideal breeding site must have adequate soil moisture throughout the developmental period to maintain the host plants and to prevent desiccation of the larvae or eggs. The soil moisture is largely influenced by soil type, slope and exposure, and most of all by the amount and distribution of rainfall in relation to loss by evaporation, transpiration and drainage. At the time of oviposition in early spring all sites are green and moist and apparently the females lay their eggs at random. Those laid in areas which remain moist complete their development. Thus, the differential drying of the hills, which is so characteristic of the California Coast ranges, delimits the areas in which *diabrotica* will survive. As a result of the varied diet acceptable to larvae, the particular kind and distribution of plants is not critical. In the grassy hills there is always an abundance of suitable foods since grass roots are ever present and various legumes are common at all sites.

The larvae of *D. 11-punctata* can develop in any of the common types of soils which occur in the region west of Brentwood. These vary from sandy loams to adobe clays. No breeding was observed in "alkali" spots. Figure 6 shows the breeding area to the west of Brentwood. The arrows, which show the migration routes from the hills, indicate that there is no correlation between breeding sites and soil type. The main differences in the various soils as breeding sites are in their ability to retain moisture. In dry years the few beetles that manage to complete their development emerge from low spots, from clay soils, or from other similar locations where the proper soil moisture was maintained. In other years of ample rainfall the sandy soils may be more favorable to development of larvae because they are warmer.

Slope affects the breeding site both in its relation to exposure to the sun and to drainage. Some *diabrotica* probably develop every year in the lower part of the wooded canyons, but such slopes are generally unfavorable. The canyons are usually too cold to allow rapid development. In 1945 there was a small emergence on the more open south slopes, but practically none on the heavily wooded north slopes. In a warm, moist spring there may be some emergence on both sides. Figure 4 shows a wheat field in the upper portion of Briones Valley. The populations of beetles which develop in cultivated fields are very variable. This variation is probably related to the time of plowing and sowing. In figure 4 the fence row shown in the foreground was a favorable breeding site in 1945 while the field itself produced no beetles. Breeding may also occur in both uncultivated

land and cultivated land near the margin of the orchard area. Certain low spots are always favorable breeding sites. They are frequently too wet to cultivate in early spring when the rest of the land is plowed.



FIG. 4. Briones Valley, west of Brentwood, California.

In unfavorable dry years such spots remain green long after the surrounding hills dry up. In 1945 beetles emerged from a few such sites when the surrounding hills had no emergence.

Since the distribution of plants, topography, soil, and temperature are practically constant, the amount and distribution of rainfall in any particular season would appear to be the most critical factor influencing the development of the spring brood. The rainfall must be considered in relation to the loss by evaporation, transpiration and drainage. The factors influencing evaporation and transpiration vary somewhat from year to year but not nearly so much as rainfall which has a mean seasonal departure of about 30 per cent (Varney, 1925). Loss by drainage depends on topography, the type of cover and the amount and distribution of rainfall. Since the first two of these are rather constant in this area, rainfall may be regarded as having a direct relation to the time of drying up of the hills. In years of low rainfall the hills dry up earlier and the size of the area where the larvae are able to complete

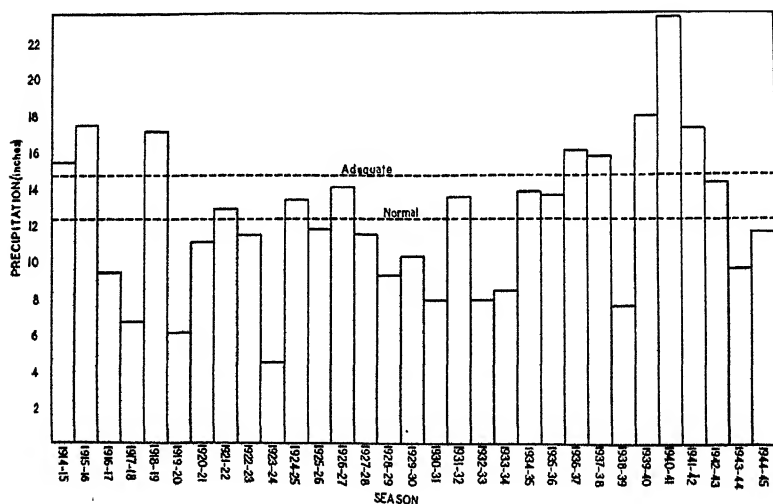


FIG. 5. Seasonal rainfall at Brentwood, California.

their development is reduced. In years of high rainfall, sections which in ordinary years would be too dry become favorable for the development of the beetles. Figure 5 illustrates the correlation between rainfall and outbreaks in the Brentwood area. When the rainfall is above the line marked adequate, experience has shown that the damage in deciduous orchards bordering the hills will be serious. If the rainfall is above normal, but not up to the line marked adequate, there will be outbreaks in years when the distribution of rain is such that the hills stay green during the critical period for *diabrotica* development. The seasons 1939-40 to 1942-43 were above normal at Brentwood and in each of these years serious damage occurred. The 1938-39 season was very dry and the 1943-44 and 1944-45 seasons were below normal. In 1938-39 there were practically no beetles in the orchards but small populations were encountered in 1943-44 and 1944-45. The infestations were large in 1937-38. From these observations it appears that the

size of the spring brood is very largely governed by rainfall, and the largest populations can be predicted to occur in years of abundant rainfall and when the spring rains are well distributed.

The spring brood reaches maturity anywhere from the middle of April to July. In the Brentwood area the earliest beetles of this brood start emerging in the hills about the first week of May, although one record is available for emergence on April 23. The peak of emergence is usually reached in approximately the third week in May and stragglers continue on into June. The time of emergence from various sites varies and is correlated with differences in soil, moisture and temperature during the larval development.

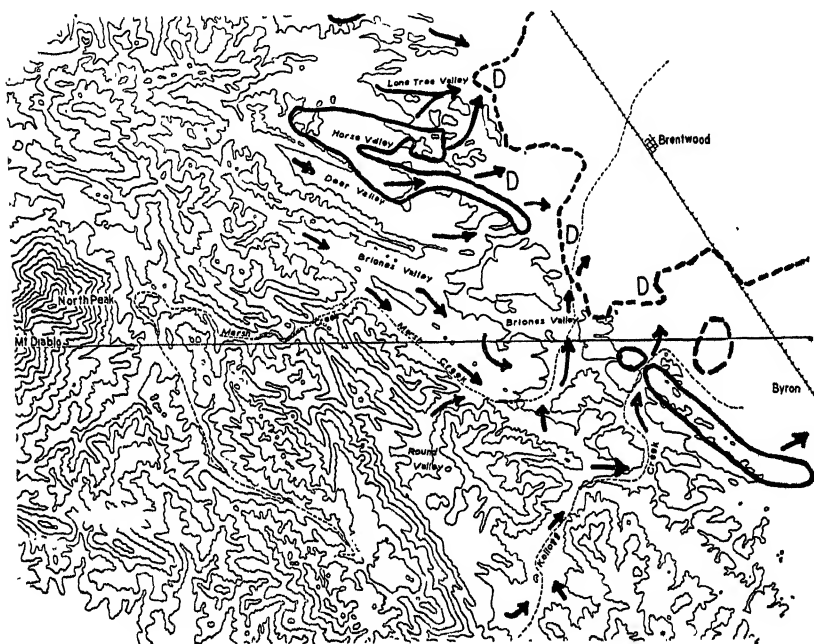


FIG. 6. The breeding area of *Diabrotica 11-punctata* in the Brentwood district. The margin of the orchard area is indicated by a heavy broken line. The sandy soils are outlined by solid lines. The migration routes of the beetles from the hills are shown by arrows.

#### CONCENTRATION AND MIGRATION OF *DIABROTICA 11-PUNCTATA*

Depending upon the amount of rainfall and the severity of the drying north winds, the hill area turns brown sometime from April to June. This drying is not uniform. It first occurs in the drier areas, the lower hills, slopes with southern exposures, lighter soils, and the ridges most exposed to the desiccating north winds. The newly emerged adults feed upon the flowers (especially the pollen) and young leaves of various plants including timothy (*Phleum pratense* L.) and many other grasses, manroot (*Echinocystis fabacea* Naud.), and mayweed (*Anthemis cotula* L.). As the hills become dry, the beetles move

to the greener locations until at last they are concentrated in small areas. They are especially attracted to succulent plants and plants with abundant pollen. These concentration points are also frequently breeding sites. They are usually low places where the soil moisture remains high for the longest period. The commonest plants fed upon by the beetles at the concentration points in the hills to the west of Brentwood are mayweed (*Anihemis cotula* L.), timothy (*Phleum pratense* L.), rye (*Lolium* and *Elymus*), mustard (*Brassica* spp.), spike-rush (*Eleocharis palustris* R. & S.), tule (*Scirpus* spp.), cattail (*Typha latifolia* L.), and Mediterranean barley (*Hordeum gussoneanum* Parl.). In dry years these concentration points are the only breeding sites.

Soil moisture content was followed at many breeding sites in 1945 in the hill area. Most of the samples were from the three inch level. All of the soils were above or very near the field capacity at the time of the last heavy rains on March 19 and April 2. From then on, the soil moisture steadily declined. There was a slight increase in soil moisture following a light rain that occurred on May 14. The march of the soil moisture through the spring is directly correlated with rainfall, as would be expected. In this year of slightly below normal rainfall the soil moisture at three inches had dropped to or below the wilting point on or before April 23 in all sample areas except one. This does not mean that all plants were wilted at this time, for many had roots at lower depths where the soil moisture content was higher. For example, on April 9, in one soil type the moisture was at the wilting point at three inches (11.09 per cent), while at six inches the moisture content was 12.84 per cent and at nine inches 13.61 per cent. However, many of the smaller roots in the range of activity of the diabrotica larvae probably had died. The plants started to turn brown in many places soon after this date and by the first week of May most of the hills were brown. One low site in Brentwood clay loam did not dry out until June. It was here the greatest emergence of beetles per unit was observed. Other stations which dropped below the wilting coefficient on April 16 had very little or no emergence of beetles.

Finally, late in the spring, the concentration points also dry up and the beetles move down out of the hills. Sell (1915) reports a similar movement at Berkeley. The initiating cause of this migration would seem to be drying up of the hills and the necessity for the beetles to find an environment favorable to the maintenance of their water balance. Their reactions at this time show a need for moisture. They frequently collect on wet ground and in one instance in Hospital Canyon to the south of Tracy, they literally covered the sides of a watering trough. Feeding on ripening fruit and the preference for young succulent foliage would also indicate that the beetles are desiccated.

The migration routes of the hill spring brood into the Brentwood fruit district are shown in fig. 6. The main factors determining the migration routes are the location of the concentration points and the topography of the land. These migration routes were located by observation in the hills and by the relative infestation in the various marginal orchards. The beetles have a tendency to follow along creek bottoms until they come to a favorable situation. The prevailing wind is from the west and the local topography usually directs this along a

southeasterly path. This happens to coincide in direction with most of the migration routes. Although a few beetles may be blown by the wind, apparently it is not an important factor in the migration. Most of the beetle movement occurs in the late afternoon when air movement is usually at a minimum. Hundreds of beetles may be seen flying slowly through the air just to the west of the orchards on a still warm evening at the peak of the migration. In some areas the trend of migration routes are against the direction of the prevailing wind. Figure 1, which indicates the degree of infestation in marginal orchards, illustrates how the severity of the infestation is related to breeding area in the drainage area above the orchard. Wherever apricot orchards occur along the periphery, diabrotica infestations occur and are greatest opposite the larger drainage areas. The essential features of these movements are indicated in figure 7.

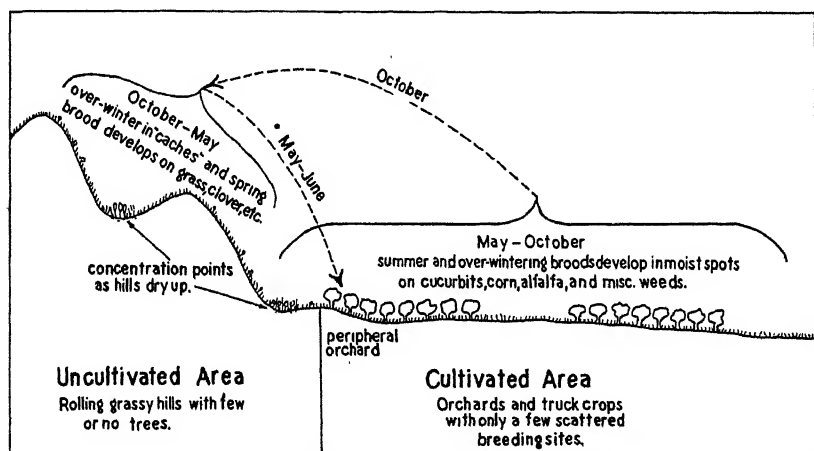


FIG. 7. A simplified diagram of the movements of *Diabrotica 11-punctata* Mannerheim in relation to deciduous fruit orchards.

#### FACTORS INFLUENCING THE POPULATIONS IN ORCHARD AREAS

There is no marked rise in the populations in the orchards until migration takes place from the uncultivated areas; from this time on, large populations can be found. The seasonal population trends for 1940 in three orchards are shown graphically in figure 8. There was a wide variation in the populations, observed in the three orchards. The two orchards with the largest populations were located near the edge of the fruit-growing district; the third was well in from the periphery. The first peak represents the migration of the beetles from the hills, and the second peak a subsequent generation in the orchard area. This second peak does not occur in apricot orchards and is most conspicuous in weedy nectarine orchards. Where apricot orchards border on nectarine orchards there may be another rise as a result of the driving of the beetles from the apricot orchards at picking time.

The beetles tend to migrate into the orchards because they offer one of the best local environments available. The leaves give an ample food supply and shade allows the beetles to escape from the heat. They are likely to be found most abundantly in the trees that have the densest foliage. Even within the trees there is a movement of the beetles towards the shady side as the temperature rises during the hottest part of the day. On many occasions in making early morning population counts it was noted that many more beetles occurred on the east than on the west side of the trees. On one occasion after a hot day (101° F.) the count on the west side of five trees averaged 517, while

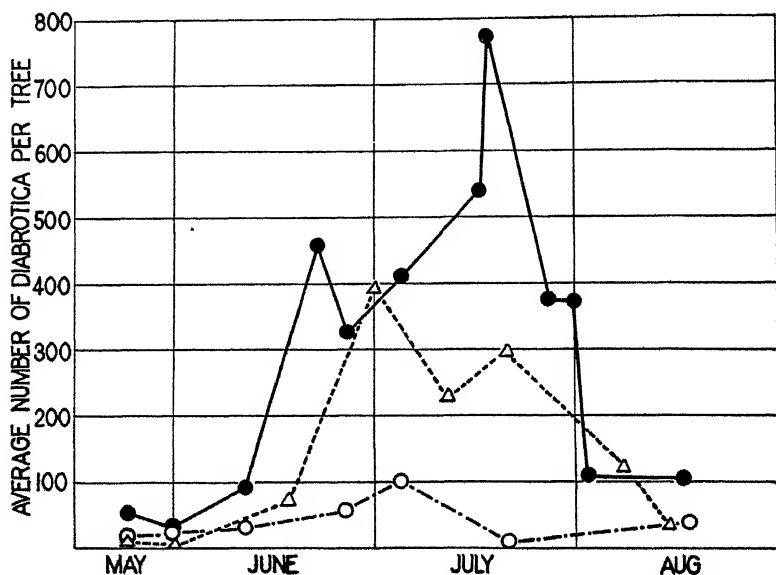


FIG. 8. *Diabrotica* population trends in three orchards at Brentwood, 1940. The graph identified by dots represents an isolated peach orchard on the periphery of the orchard area; that marked by triangles represents a nectarine orchard also on the periphery of the orchard area; and the graph indicated by circles represents a nectarine orchard well in from the periphery of the orchard area.

on the east side the count was 1074. This distribution undoubtedly resulted from beetles moving to the east side of the trees to escape the hot afternoon sun.

Because the denseness of foliage is an important factor, peach and nectarine trees generally offer a more suitable environment for the beetles than do apricot trees. In apricot trees the beetle population falls off abruptly as soon as the crop is harvested. While ripe or nearly ripe fruit is still in the tree the beetles find conditions suitable. Ripe fruit is preferred over green fruit since it furnishes ample moisture and the feeding punctures can be utilized for protection. Following harvest, most apricot trees are in a partially wilted and open condition and no longer offer a suitable environment. The beetles tend to leave such trees. Nectarine and peach trees on the other hand may furnish a

suitable environment before, during, and after harvest. In contrast to apricot trees, very large populations may be encountered both before the fruit is ripe and after harvest.

Cool weather during the month of June when the fruit is ripe markedly reduces the amount of damage. When temperatures are high in June, damage is more severe. For this reason it is difficult to establish the economic population level; in a cool harvest season a much higher population is needed to cause economic damage than if the season is a warm one.

In some years it would appear that, in addition to the spring brood in the hills, a brood of *diabrotica* develops in the orchard area. This brood apparently supplements the numbers from the uncultivated area in outbreak years because of increased breeding areas available in the cultivated regions, along fence rows, in pastures, in weedy orchards, etc. Clean cultivation and general reduction of weeds would reduce the size of this brood.

A very important consideration in the damage to deciduous fruits is the time of ripening. Under normal conditions cherries are not injured unless they ripen very late or other special local conditions prevail. This is because they mature before the beetles migrate into the fruit area, although late cherries are occasionally injured. Apricots, nectarines and early peaches are badly damaged. Late peaches, apples, and pears are rarely damaged.

If other suitable crops, particularly curcubits, alfalfa or sugar beets, intervene between the orchards and the hills, the migration into the orchards may be markedly reduced.

#### SUMMARY

*Diabrotica 11-punctata* Mannerheim is a serious local pest of deciduous fruits in certain areas of California. In most of central California there are three generations a year. The winter is passed in the adult stage. The first spring generation occurs largely in the uncultivated regions. Unless there is adequate rainfall and a good growth of vegetation in the winter and early spring, the first brood of beetles is small. This first brood appears during the latter part of April through May and most of June. In the uncultivated areas the beetles concentrate in large numbers on the flowers of such plants as timothy and mayweed. As these plants dry up in the late spring the beetles move into the cultivated areas. Since the driving force would seem to be the need for moisture, many beetles move into deciduous fruit orchards and seriously damage the ripe fruit. A large rolling, grassy, uncultivated area in conjunction with a relatively small orchard area favors severe attacks. Variations in rainfall from season to season affect the size of the suitable breeding area and the consequent populations. Other crops, such as alfalfa, may absorb a large portion of the migrating beetles and reduce damage. Apricots are the fruit most seriously attacked, with cherries, nectarines and peaches also damaged to some degree.

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In systematics such vague expressions as "larger," "smaller," and "more or less," have been replaced to a large extent by attempts to indicate measurable comparisons as ratios or in numerical terms. Too often, however, the micrometer has existed only in the retina of the systematist rather than in his optical instruments, and that retinal micrometer may be notoriously unreliable or unstable. When exact measurements are taken an advance in technique is made, but perhaps we do not always know just how to obtain these measurements or what to do with them once they are obtained.

The present work may prove to be one of the important contributions to the taxonomy of the future. To be sure, as the authors remark, systematic problems cannot "be entirely solved or verified by statistical methods," as "there is nothing to replace the biologists' familiarity with and understanding of the variation of living organisms, the many factors influencing this variation, and the intricate ramifications." It must be kept in mind, however, that the species is not a cabinet specimen or a series of such specimens, but rather a complex of natural populations. Though the ideal way of evaluating these populations would be through genetical studies, such a course, in the light of our limited knowledge of genetics, is obviously impractical. We must, therefore, rely on morphological, biological, ecological, and otherwise defined differential characters, most of which are subject to application of statistical methods. That these methods are successful, has been demonstrated by application to vertebrate taxonomy and palaeontology. They should be equally useful in insect taxonomy just as soon as the necessary spade-work has been done and statistically-minded workers on the various groups are available.

The taxonomist should not be frightened by the intricacies of statistics. He can disregard those phases of the subject which deal with the planning and plotting of experiments, since he has available only data derived from observations of samples obtainable from nature. The "Introduction to Quantitative Systematics" serves to provide the necessary mechanism for obtaining and handling such data as the taxonomist can use.

The presentation is clear and should be understandable even to one who has not progressed in his mathematics beyond college algebra. It is not easy reading, but it is not unduly involved. Terms are defined whenever necessary. Methods of obtaining data, with regard to homogeneity, size, and bias of sampling, the selection of characters, and the mechanism of making and recording measurements are described. Since the data, in their frequency distribution, usually approach a normal frequency curve, the use of various measures of this curve such as central tendency (mean, median, and mode), of variation (standard deviation), of variability (coefficient of variability), and of reliability (standard errors), is described. Small samples, including single specimens, may be handled on the basis of the laws of probability. The application of these techniques should result in a more reliable method of evaluating character differences than could be obtained from a consideration of mean differences.

The methods described by the authors will not find favor among workers who are dealing with comparatively unknown faunas. Moreover, there are some groups in which differences are so obvious that the application of statistical methods is unnecessary. Because of the greater availability of materials, however, and our changing concepts of the fineness of specific differences in many groups many problems become adaptable to these methods. Perhaps herein may be the hope of a relatively objective solution of many hitherto unsolvable problems.—M. T. J.

# FACTORS GOVERNING THE INDUCTION OF DIAPAUSE IN THE ORIENTAL FRUIT MOTH<sup>1</sup>

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Diapause is a physiological state of arrested development which enables an organism to survive more easily a period of unfavorable conditions. Once an organism has entered diapause it usually has to remain in that state for a certain period, regardless of the conditions of the environment. In some species diapause is broken by exposure to particular conditions, notably cold. A few species may remain in diapause more than one year.

The term "diapause" was first used by Wheeler (1893) to specify a stage in the embryonic development of *Conacephalus*. Henneguy (1904) extended the term by applying it to the state of arrested development occurring in the eggs of *Bombyx* and in the larvae of *Liparis*. It has since been further extended to cover similar phenomena occurring at any stage of the life cycle of an organism.

Insects in diapause are characterized by a low metabolic rate, greatly diminished activity, practical cessation of development, and an increased ability to survive unfavorable environmental conditions.

Many theories have been advanced to account for the initiation of diapause, since it obviously is not always induced directly by the onset of the unfavorable conditions themselves. In many cases diapause that will serve to carry an organism through the winter starts long before that season begins.

This paper deals chiefly with the factors controlling the induction of diapause in the oriental fruit moth, *Grapholitha molesta* (Busck). These factors are temperature and photoperiod, which operate during the larval feeding period. Some data on the induction of diapause in the codling moth, *Carpocapsa pomonella* (L.), the greenbottle fly, *Lucilia sericata* Meig., and the vegetable weevil, *Listroderes obliquus* Klug, are also presented.

## REVIEW OF LITERATURE

Published work on diapause and related phenomena in insects is extensive. This writer does not intend to review all the work, but attempts, rather, to organize and classify the results reported, particularly on the basis of the factors reported as inducing diapause. Reference will be made to various publications illustrating the points made. For more complete bibliographies the reader is referred to Uvarov (1931), Wigglesworth (1939), Prebble (1941), and Bonnemaison (1945).

<sup>1</sup>Paper No. 610, University of California Citrus Experiment Station, Riverside, California.

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*Developmental Fatigue.*—The first investigator to advance the theory that diapause might be caused by a developmental fatigue brought about by the accumulation of waste products in the body appears to have been Sajo (1896), who was working with the chrysomelid *Entomoscelis adonidis* Fall. This idea was developed by Robaud (1922), who worked with various species of flies, particularly with *Lucilia sericata* Meig. He postulated that this developmental fatigue is an autointoxication caused by the accumulation of metabolic wastes which build up faster than they are eliminated during active growth, so that a period of rest (diapause) is needed to allow elimination to catch up. He also believed that this developmental fatigue is inherited and continues to build up during the several summer generations. This work has been rather well discredited by Cousin (1932), who showed that hibernation in *Lucilia* is caused by environmental factors.

*Diapause Factor or Hormone.*—Bodine (1932) studied diapause in the eggs of *Melanoplus differentialis* (Thos.) and advanced the theory that there is a diapause factor (X factor) present in the diapause-type eggs of that species at the time that they are laid. If these eggs are held at comparatively high temperatures, the amount or potency of the diapause factor increases until it passes a threshold at the "three-weeks" stage and stops embryonic development. The diapause factor is gradually dissipated after this point and eventually allows development to resume. Exposure to low temperature at any time, either before or after the "three-weeks" stage, rapidly destroys the diapause factor, and development resumes as soon as the temperature is raised.

Andrewartha (1943), working with the eggs of another grasshopper, *Austroicetes cruciata* Sauss., offered another explanation. He believed that the arrest of embryonic development is caused by an unfavorable condition of the yolk, which is corrected by exposure to cold.

Salt (1947), working with *Cephus cinctus* Nort., has further developed Bodine's theory. He postulates that diapause in this species is controlled not only by an X factor similar to that envisioned by Bodine, but also by a Y factor, which breaks down more slowly than does the X factor but at a constant rate, regardless of temperature. He was able to reinstate diapause by exposure to very high temperatures at any time before the Y factor was eliminated. One might suggest that the Y factor could be the material from which the X factor is formed.

The evidence indicates that a hormone or diapause factor is often present to control diapause, but, as we shall see below, many things may induce its formation.

*Inheritance of Behavior Patterns in Diapause.*—The development and behavior patterns in regard to diapause are inherited as are all other similar patterns. There are many insect species which have but one generation per year, with a considerable part of each year spent in diapause. In these species it may well be that each individual must enter diapause, the adjustment to the seasons occurring at the time the insect resumes development rather than at the time it enters diapause. An example of this is found in *Porthetria dispar* (L.), which has but one generation per year, remaining in the egg stage from July until the following spring. Goldschmidt (1933) stated that the length of the diapause is determined genetically and is different in the various races

of this species. Those races that live where the winters are mild require many more hour-degrees of heat to cause the eggs to hatch than do those that experience severe winters. Andrewartha (1943) found that the eggs of the one-generation grasshopper *Austroicetes cruciata* Sauss. always enter diapause, the embryo developing very slowly through the hot season so that when cold weather appears the egg is in such a condition that low temperature soon breaks the diapause.

A few insect species are known in which there are both single-generation strains (univoltine or monovoltine) and multiple-generation strains (multivoltine or polyvoltine). One of these is the silkworm, *Bombyx mori* L., in which the diapause occurs in the egg. The univoltine strains of the silkworm have but one generation annually, and the diapause occurs in every generation. Multivoltine strains have two to several generations annually: eggs laid in the summer hatch in a short time; those laid in the fall enter diapause. The inheritance of voltinism in the silkworm is somewhat complex, there being some evidence for somatic inheritance from the mother. It is reported by Uyema (1926) that if the ovaries from an individual of one race are transplanted to an individual of another race during the larval stage the eggs produced show the voltinism of the moth in which they are grown rather than that of their true ancestors. The likelihood that a given batch of eggs will enter diapause is also influenced by the temperature at which the eggs and larvae of the preceding generation were held.

In the case of *Pyrausta nubilalis* (Hbn.), a species which enters diapause as full-fed larvae, it is well known that some areas are occupied by one-generation strains and others by two-generation strains. Babcock (1924) reported that when specimens of the one-generation strain were transferred to an area occupied by the two-generation strain, and vice versa, they persisted in retaining the same seasonal histories that they had shown in their original environments. Arbutnot (1944) found that in Connecticut the population is homozygous for multiple generations, while in Ohio it is mixed, containing factors for both single and multiple generations. He was able to isolate a homozygous single-generation strain from Ohio population, and found that the genetic factors responsible for the single generation are recessive. O'Kane and Lowry (1927), working with this insect in New Hampshire, showed that although the population was homozygous for multiple generations, only a part of them actually went through two generations per year, the rest having but one. All the larvae from the first eggs of the season pupated that same summer and produced a second generation, while larvae from eggs that hatched after a certain date, usually about July 20 to 25, entered diapause and so had only one annual generation. Apparently, environmental factors are involved in the induction of diapause in this species, at least in the multiple-generation strain.

Prebble (1941) found that some strains of the European spruce sawfly, *Diprion hercyniae* (Htg.) entered diapause more readily than other strains.

*Effect of Temperature on the Induction of Diapause.*—Most insects living in temperate or frigid climate undergo an arrest of development during the winter. If this is caused directly by the low temperature

and is brought to an end whenever the temperature again rises, it is called "quiescence" and is not diapause. Some instances have been reported, however, in which low temperature induces diapause.

Dawson (1931) was able to induce pupal diapause in *Telea polyphemus* (Cramer) by subjecting the last larval stadium to declining temperatures. Ditman, Weiland, and Guill (1940) reported that diapause during the pupal period of the corn earworm, *Heliothis armigera* (Hbn.), is induced by low temperature during the larval feeding period. Prebble (1941) found that diapause in emergent (polyvoltine) stocks of *Diprion hercyniae* (Htg.) is determined environmentally, and showed that, at least under certain conditions, larval feeding at low temperatures favors entry into diapause as full-fed larvae.

*Food and Water.*—Food and water are closely related in insect economy since most of the water taken by insects is taken in the food. Strelnikov (1936) reported that when *Loxostege sticticalis* (L.) was fed on plants having a high moisture content no diapause was induced, but when the moisture content of the plants was low the insects entered diapause. He stated that in this species diapause is induced under natural conditions by insufficiently moist food, by low temperature, and by food having increased nutritive value.

Squire (1940) reported that diapause of the full-fed larvae of the pink bollworm, *Pectinophora gossypiella* (Saund.), is independent of the season and depends on the moisture content of the seeds in which they feed. If the seeds are comparatively mature, the larvae enter diapause, but if the seeds are immature and moist, they do not. Diapause in this species is closely related to changes in the host plant, and only indirectly to climatic changes.

Van der Goot (1925) reported that the white rice-borer, *Scirpophaga innotata* Wlk., enters diapause when the larvae feed in maturing rice plants. Once in diapause they remain for at least four and one-half months, and resume development in response to the first showers of the rainy season.

*Photoperiod.*—The earlier reports of the effect of the length of the photoperiod on diapause in insects concern aphids, in which the situation is complex. Aphids reproduce parthenogenetically throughout the summer, only females being produced. In the fall oviparous females and males are produced, also by parthenogenesis; they mate, and the females produce the eggs, which enter diapause and thus enable the species to pass the winter. Marcovitch (1924) found that *Aphis forbesi* Weed and three other species of aphids produced males and oviparous females when the days were artificially shortened to 7½ hours. Davidson (1929) reported similar results. Wadley (1931) found that, in the production of sexuals in *Toxoptera graminum* (Rond.), the temperature has some influence, but that the principal factor is the photoperiod, which acts either on the mother or on the individual before birth.

Baker (1935) found that he could break the diapause in young larvae of the treehole mosquitoes *Orthopodomyia signifera* Coq. and *Anopheles barberi* Coq. by using six hours of artificial light to prolong winter days. Dickson and Sanders (1945) reported that they could control the induction of diapause in *Grapholita molesta* (Busck) by regulating temperature and photoperiod during the larval feeding period.

## MATERIALS AND METHODS

All experiments were conducted in insulated cabinets in which constant temperatures and humidities were maintained. The illumination used was entirely artificial, and its intensity was controlled.

Larvae of the oriental fruit moth and of the codling moth were grown in small, immature apples, which were held in cold storage until needed. The full-fed larvae were collected each morning as they emerged and allowed to spin in strips of a celluloid device made in imitation of corrugated paper.

Larvae of the greenbottle fly, *Lucilia sericata*, were grown in fish heads or rabbit heads, and the full-fed larvae were allowed to crawl into damp sand. Larvae and puparia were sieved from the sand for observation.

Vegetable-weevil larvae were grown on wild mustard in battery jars. The adults were allowed to gather under trash in the bottom of these same containers.

The constant-temperature cabinets held the temperature reasonably well, the maximum variation amounting to about one degree Centigrade. The temperature recorded in this paper as 24° C. represents a temperature which varied from 24° C. to 25° C., but which was usually near 24°. The intensity of illumination used in most of the experiments is recorded as 26 f. c. (foot-candles). This represents a mean of the intensity of illumination, which varied above and below 26 f. c., depending on the age of the bulb, the cleanliness of the glass window, and the location of the growing insects in the cabinets. A tungsten-filament lamp was used in all experiments except those in which the use of another light source is noted. Illumination was measured by a General Electric photometer, a barrier-layer type, DW-47. The light intensity recorded represents the light intensity reaching the top surface of the fruit in which the larvae were feeding.

Certain data are presented in more than one table in order to facilitate comparisons.

## EXPERIMENTAL RESULTS

*The oriental fruit moth*

*Behavior under Natural Conditions.*—The oriental fruit moth, *Grapholitha molesta* (Busck), feeds in the twigs and fruit of several rosaceous plants, its favorite host being the peach. There are from two to seven generations annually, the number depending on the locality. The insect passes through the several spring and summer generations without entering diapause. Beginning in the late summer or early fall, an increasing proportion of the emerged, full-fed larvae enter diapause and do not pupate until spring. It has been advantageous to this species to develop the habit of entering diapause while the weather is still warm, for if the insects remained active until the onset of cold weather the population would be greatly reduced by the scarcity of suitable food. As will be shown in this paper, the proper timing has been achieved by the use of the shortened length of day in the late summer as a stimulus to enter diapause.

A typical record of the onset of diapause in the fall is shown in Table I and figure 1. All larvae that emerged earlier than those shown

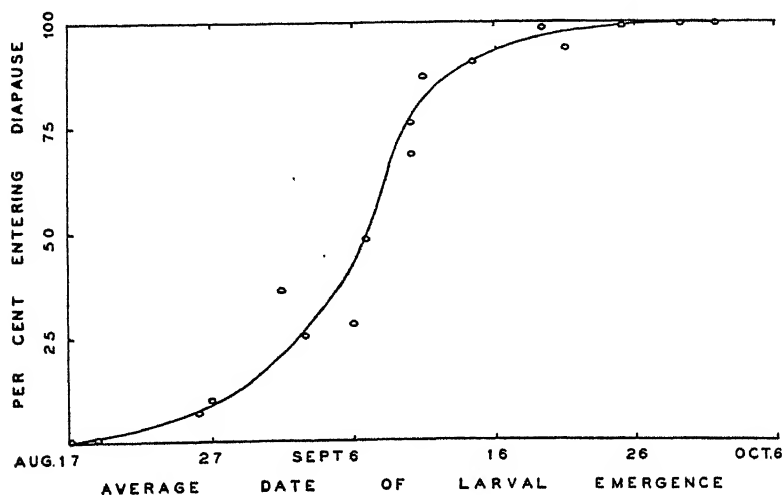


FIG. 1. Relation between the average date of emergence of full-fed larvae of the oriental fruit moth grown under outside conditions at Riverside, California, and the percentage of larvae that entered diapause.

TABLE I

RECORD OF BATCHES OF ORIENTAL FRUIT MOTH LARVAE GROWN UNDER OUTSIDE CONDITIONS AT RIVERSIDE, CALIFORNIA, SHOWING RELATION BETWEEN DATE OF EMERGENCE AS FULL-FED LARVAE AND ENTRANCE INTO DIAPAUSE

DATE EGGS HATCHED (1944)	LARVAL FOOD	FULL-FED LARVAE		
		Average Date of Emergence (1944)	Total Number	Per Cent Entering Diapause
Aug. 1	Green apples.....	Aug. 17	47	0.0
Aug. 4	Ripe peaches.....	Aug. 16	91	0.0
Aug. 4	Green apples.....	Aug. 19	79	1.3
Aug. 8	Green apples.....	Aug. 26	98	7.1
Aug. 11	Green apples.....	Aug. 27	73	9.6
Aug. 15	Green apples.....	Sept. 3	205	25.4
Aug. 16	Green apples.....	Sept. 6	58	27.6
Aug. 18	Ripe peaches.....	Sept. 1	114	36.0
Aug. 18	Green apples.....	Sept. 7	113	47.8
Aug. 22	Green apples.....	Sept. 11	91	87.0
Aug. 25	Green peaches.....	Sept. 10	143	76.9
Aug. 25	Ripe peaches.....	Sept. 10	121	69.4
Aug. 25	Green apples.....	Sept. 14	53	90.6
Aug. 29	Green apples.....	Sept. 19	110	97.6
Sept. 1	Green apples.....	Sept. 21	101	94.1
Sept. 5	Green apples.....	Sept. 25	113	99.1
Sept. 9	Green apples.....	Sept. 29	126	100.0
Sept. 12	Ripe peaches.....	Oct. 2	173	100.0

in this table pupated a few days after emergence; all those that emerged later, entered diapause. The temperature when diapause first appeared was almost as warm as that of midsummer. The type of food on which the larvae were fed appears to have had no effect on their entry into diapause.

*Effect of Hours of Light per Day at Medium Temperatures.*—Experimental data show that at medium temperatures the proportion of larvae entering diapause is determined by the number of hours of light per day to which they are exposed during the larval feeding period. (Table II). In figure 2 some of the data from Table II are shown in graphic form.

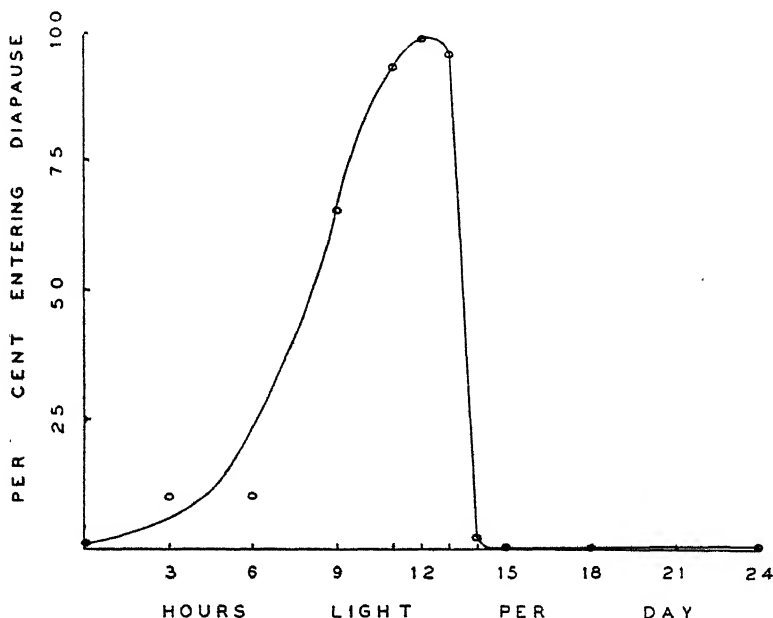


FIG. 2. Effect of exposure to various daily photoperiods, during larval feeding period, on the percentage of oriental fruit moth larvae entering diapause. Larvae grown at a medium temperature of 24° C.; prepupal period, 24° C.; illumination, 26 f. c.

When grown in total darkness or total light, very few of the larvae enter diapause. This indicates that basically the larvae tend to pupate without entering into a state of diapause. The fact that a few of the larvae do enter diapause when grown without any photoperiod indicates that there is also present an inherent tendency to enter diapause. As the daily photoperiod is increased, the proportion of the larvae entering diapause increases until the hours of light per day number about 12. As the photoperiod is increased to more than 13 hours of light per day, the percentage of larvae entering diapause drops very sharply to practically zero, and this almost total absence of diapause is maintained



as the photoperiod is increased beyond 14 hours per day. This response to the number of hours of light per day explains the behavior in the field very well, particularly when the studies on the minimum effective intensity of illumination (see p. 523) are considered.

TABLE II

EFFECT OF THE NUMBER OF HOURS OF LIGHT PER DAY DURING LARVAL FEEDING PERIOD, AT VARIOUS MEDIUM TEMPERATURES, ON THE PERCENTAGE OF ORIENTAL FRUIT MOTH LARVAE ENTERING DIAPAUSE\*

HOURS PER DAY OF		TOTAL LARVAE	LARVAE ENTERING DIAPAUSE	
Light	Darkness		Number	Per Cent
Temperature, 21°C.				
0	24	99	15	15.2
6	18	72	68	94.4
9	15	91	91	100.0
12	12	101	99	98.0
15	9	72	2	2.8
18	6	89	4	4.5
24	0	49	7	14.3
Temperature, 24°C.				
0	24	423	8	1.9
3	21	293	32	10.9
6	18	864	95	11.0
9	15	302	203	67.2
11	13	118	110	94.2
12	12	745	735	98.7
13	11	380	367	96.6
14	10	230	9	3.9
15	9	147	0	0.0
18	6	137	1	0.7
24	0	340	1	0.3
Temperature, 26°C.				
0	24	247	2	0.8
$\frac{1}{4}$	$23\frac{3}{4}$	86	8	9.3
$\frac{1}{2}$	$23\frac{1}{2}$	94	7	7.4
1	23	134	7	5.2
3	21	109	36	33.0
6	18	78	49	62.8
9	15	131	106	80.9
12	12	108	100	92.6
15	9	96	5	5.2
18	6	80	0	0.0
24	0	182	2	1.1

\*Larvae held at given temperatures throughout growth and prepupal period; illumination, 26 f. c.

*Effect of Hours of Light per Day at High and Low Temperatures.*—The influence of the photoperiod on entrance into diapause is dominant at medium temperatures, but when the larvae are grown at high or low temperatures it loses most of its effect (Table III). Almost 100 per cent of the larvae grown at medium temperatures (21°, 24°, and 26° C.), with 12 hours illumination per day, entered diapause; but neither those grown at 12° C. nor those grown at 30° C., exposed to the same photoperiod, entered diapause in appreciable numbers.

TABLE III

EFFECT OF VARIOUS EXTREME TEMPERATURES, DURING LARVAL FEEDING PERIOD, ON THE PERCENTAGE OF ORIENTAL FRUIT MOTH LARVAE ENTERING DIAPAUSE\*

TEMPERATURE, DEGREES C.	TOTAL LARVAE	LARVAE ENTERING DIAPAUSE		
		Number	Per Cent	Unweighted Mean Per Cent
Light: 12 Hours—Darkness: 12 Hours				
12	49	1	2.0)	2.4
12	34	1	2.9)	
21	101	99	98.0	98.0
24	364	364	100.0)	98.7
24	381	371	97.4)	92.6
26	108	100	92.6)	
30	37	0	0.0)	1.4
30	93	3	3.2)	
30	199	2	1.0)	
Light: 15 Hours—Darkness: 9 Hours				
12	39	1	2.6)	1.3
12	51	0	0.0)	
21	72	2	2.8	2.8
24	63	0	0.0)	0.0
24	84	0	0.0)	
26	96	5	5.2	5.2
30	50	0	0.0)	0.0
30	46	0	0.0)	

\*Photoperiods during larval feeding period, as given; illumination, 26 f. c. Temperature during prepupal period, 24°C. (21°C. for larvae grown at 21°C. or 26°C.).

The absence of diapause in oriental fruit moth larvae grown at low temperatures may be an advantage to the species, since belated individuals feeding during the cold of winter do not enter diapause and thus are not unduly delayed in their spring emergence. Larvae grown at low temperatures show a sensitivity to low temperatures in inducing a delay in pupation (see section on "Temperature During the Prepupal Period").

The lack of sensitivity to photoperiod at high temperatures may be a disadvantage to the species in certain localities, since it may unduly

TABLE IV

EFFECT OF LOW "NIGHT" TEMPERATURE (2°C.), DURING LARVAL FEEDING PERIOD, ON THE PERCENTAGE OF ORIENTAL FRUIT MOTH LARVAE ENTERING DIAPAUSE\*

HOURS PER DAY OF		TOTAL LARVAE	LARVAE ENTERING DIAPAUSE		
Light (at 26°C.)	Darkness (at 2°C.)		At Varying Temperatures of 26° and 2°C.		At a Constant Temperature of 26°C. (Same Photoperiods)†
			Number	Per Cent	Per Cent
6	18	98	98	100 0	80.9
9	15	119	119	100.0	92.6
15	9	82	60	73.2	5.2
18	6	57	30	52.6	0.0

\*Feeding larvae held at 26° C. during hours of light and at 2° C. during hours of darkness; prepupal period, 21° C.; illumination, 26 f. c.

†Data from Table II, for comparison.

TABLE V

EFFECT OF INCREASING, DECREASING, AND CONSTANT PHOTOPERIODS ON PERCENTAGE OF ORIENTAL FRUIT MOTH LARVAE ENTERING DIAPAUSE\*

PHOTOPERIOD†	TOTAL LARVAE	LARVAE ENTERING DIAPAUSE	
		Number	Per Cent
Temperature During Larval Feeding Period, 21°C.			
Constant.....	101	99	98.0
Increased 5 minutes each day....	108	108	100.0
Decreased 5 minutes each day...	101	99	98.0
Temperature During Larval Feeding Period, 26°C.			
Constant.....	108	100	92.6
Increased 5 minutes each day....	106	94	88.7
Decreased 5 minutes each day...	141	130	92.2

\*Temperature during prepupal period, 21°C.

†Average photoperiod, 12 hours per day; illumination, 26 f. c.

delay the onset of diapause in climates where very high temperatures persist into the fall. On the other hand, it may allow continuous development in tropical areas.

In natural surroundings the oriental fruit moth is seldom exposed to constant temperatures, the temperature being considerably lower at night than during the day. It was not possible to make a series of tests under such conditions, but in one test a night temperature well below the threshold of development was used. The results of this test are shown in Table IV. Evidently, the low temperature during the period of darkness tended to induce diapause, even though it was low enough to stop all development.

*Increasing, Decreasing, and Constant Photoperiods.*—Experiments were conducted to determine the effect of small increases or decreases in the photoperiod each day, in comparison with a constant photoperiod, on the percentages of larvae entering diapause. The results (Table V) showed that it is the actual length of the photoperiod rather than its increase or decrease that affects the larvae.

TABLE VI

RESULTS OF EXPERIMENTS TO DETERMINE EFFECT OF DIAPAUSE-INDUCING AND DIAPAUSE-PREVENTING PHOTOPERIODS, DURING VARIOUS PARTS OF THE LARVAL FEEDING PERIOD, ON THE PERCENTAGE OF ORIENTAL FRUIT MOTH LARVAE ENTERING DIAPAUSE\*

DURATION OF PHOTOPERIODIC CONDITIONS		TOTAL LARVAE	LARVAE ENTERING DIAPAUSE	
Diapause-Inducing (12 hours light per day)	Diapause-Preventing (15 hours light per day)		Number	Per Cent
Last 0-5 days.....	First 12 days.....	156	0	0.0
Last 4-9 days.....	First 8 days.....	118	2	1.7
Last 8-13 days.....	First 4 days.....	85	4	4.7
First 12 days.....	Last 0-6 days.....	185	179	96.8
First 8 days.....	Last 4-10 days.....	55	38	69.1
First 4 days.....	Last 8-13 days.....	178	3	1.7

\*Temperature during larval feeding period and prepupal period, 24° C., illumination, 26 f. c.

*Cumulative Effect of the Photoperiod.*—An experiment was conducted to determine whether the photoperiod is operative during all or only part of the larval feeding period. Results (Table VI) showed that practically no diapause was induced unless the larvae were exposed to a diapause-inducing photoperiod in the early part of their feeding period, but that such a photoperiod had some effect if applied any time during the feeding period. Although there does not appear to be an actually critical point, the early part of the period is more critical than any other part.

*The Color of the Light.*—Experiments were conducted to determine which wavelengths of light are most capable of affecting the induction of diapause in this species. Oriental fruit moth larvae were exposed, during their feeding period, to 12 hours' illumination per day with light which had been filtered through various glass filters. The source of

TABLE VII

EFFECT OF ILLUMINATION WITH LIGHT OF VARIOUS WAVELENGTHS, 12 HOURS PER DAY DURING LARVAL FEEDING PERIOD,  
ON PERCENTAGE OF ORIENTAL FRUIT MOTH LARVAE ENTERING DIAPAUSE\*

No.	FILTER	LIGHT, IN Å			INTEN- SITY OF ILLUMI- NATION, IN F. C.	TOTAL LARVAE	LARVAE ENTERING DIAPAUSE		
		Practical Limit	Peak	Practical Limit			Number	Per Cent	Unweighted Mean Per Cent
....	Ultra Violet.....	.....	3,660	.....	100	194	1	0.5	0.7
....	Ultra Violet.....	.....	3,660	.....	30	212	2	0.9	
4308	Light Shade Blue Green.....	.....	4,300	6,300	15	139	139	99.3	99.0
4308	Light Shade Blue Green.....	3,400	4,300	6,300	15	84	83	98.8	
3962	Medium Shade Aklo.....	.....	5,000	7,600	12	69	57	82.6	87.0
3962	Medium Shade Aklo.....	.....	5,000	7,600	12	118	108	91.6	
3484	Traffic-Shade Yellow.....	.....	5,800+	.....	30	144	132	91.7	92.7
3484	Traffic-Shade Yellow.....	5,300	5,800+	.....	30	113	106	93.8	
2412	Lantern Red.....	.....	6,600+	.....	12	174	29	16.8	20.1
2412	Lantern Red.....	6,000	6,600+	.....	12	141	33	23.4	
2540	Heat-Transmitting.....	7,500	14,000	40,000	91.5†	19	0	0.0	1.3
2540	Heat-Transmitting.....	7,500	14,000	40,000	91.5†	39	1	2.6	
....	.....	.....	.....	.....	26	364	364	100.0	98.7
....	.....	.....	.....	.....	26	381	371	97.4	

\*Temperature during larval feeding period and prepupal period, 24°C.

†Gram-caloric-hours per cm.<sup>2</sup>

illumination was a 200-watt, gas-filled tungsten filament lamp, except in the experiments with ultraviolet light, in which a mercury vapor lamp was used, and with infrared light, in which a heater cone was used. Results of these experiments are shown in Table VII.

Neither the ultraviolet light nor the infrared was effective in inducing diapause. Of the visible light, the shorter wavelengths were more effective than the longer. The "lantern red" filter, which cut off all light having wavelengths shorter than 6,000 Å, in the yellow orange, induced diapause in only about one-fifth of the larvae, and even the light passed through the "traffic-shade yellow" filter was less effective in inducing diapause than was light containing the blue end of the spectrum.

*Intensity of Illumination.*—It was considered important to discover the lower limit of intensity at which illumination is effective in inducing diapause, so that the length of the photo-periodically effective twilight

TABLE VIII

EFFECT OF VARIOUS INTENSITIES OF ILLUMINATION, 12 HOURS PER DAY DURING LARVAL FEEDING PERIOD, ON THE PERCENTAGE OF ORIENTAL FRUIT MOTH LARVAE ENTERING DIAPAUSE\*

INTENSITY OF ILLUMINATION, IN F.C.	TOTAL LARVAE	LARVAE ENTERING DIAPAUSE		
		Number	Per Cent	Unweighted Mean Per Cent
26	364	364	100.0	98.7
26	381	371	97.4	
3	207	186	89.9	
3	308	286	92.9	88.5
3	250	207	82.8	
1	124	1	0.8	1.1
1	146	2	1.4	
0	179	5	2.8	2.0
0	245	3	1.2	

\*Temperature during larval feeding period and prepupal period, 24°C.

might be estimated. As pointed out by Greulach (1942), the total photoperiodically effective daylight is longer than the time between sunrise and sunset. He found that, in Ohio in the summer, the total (morning and evening) photoperiodically effective twilight ranges from 20 minutes to one hour, the variation depending on the amount of cloudiness. He used 1 f. c. as a base, since light is effective on plants down to about 1 f. c.

The results of experiments to determine the minimum effective intensity of illumination on larvae of the oriental fruit moth are shown in Table VIII. Illumination having an intensity of 3 f. c. was effective in controlling the onset of diapause, but that of 1 f. c. was not. This means that, for the oriental fruit moth, the photoperiodically effective length of the day is almost as long as that found by Greulach for plants. On a clear summer evening in southern California it takes only about two minutes for the intensity of illumination to sink from 3 f. c. to 1 f. c.

The inclusion of the morning and evening twilight periods in the length of the day makes the experimentally demonstrated effect of the photoperiod correspond very well with the response of the oriental fruit moth to natural illumination throughout the season.

*Mode of Action of the Photoperiod.*—Series of experiments were conducted in an attempt to discover how the photoperiod operates in governing the induction of diapause. When a day length of 24 hours is used, periods of illumination of approximately 12 hours per day induce a high percentage of diapause. With these photoperiods the ratio of light to darkness is at or near one to one. Experiments were therefore

TABLE IX

EFFECT OF VARIOUS "DAY" LENGTHS, HAVING RATIO OF HOURS LIGHT TO HOURS DARKNESS ALWAYS 1:1 DURING LARVAL FEEDING PERIOD, ON THE PERCENTAGE OF ORIENTAL FRUIT MOTH LARVAE ENTERING DIAPAUSE\*

HOURS LIGHT	HOURS DARKNESS	TOTAL "DAY" LENGTH, IN HOURS	TOTAL LARVAE	LARVAE ENTERING DIAPAUSE		
				Number	Per Cent	Unweighted Mean Per Cent
15	15	30	185	4	2.2	1.4
15	15	30	143	1	0.7	
14	14	28	171	29	17.0	16.7
14	14	28	195	32	16.4	
13	13	26	100	73	73.0	78.0
13	13	26	77	64	83.1	
12	12	24	364	364	100.0	98.7
12	12	24	381	371	97.4	
11	11	22	129	127	98.4	98.7
11	11	22	107	106	99.1	
10	10	20	243	155	63.8	65.2
10	10	20	141	94	66.7	
9	9	18	101	4	4.0	2.9
9	9	18	206	4	1.9	
6	6	12	89	5	5.6	4.0
6	6	12	82	2	2.4	
3	3	6	149	3	2.0	2.0

\*Temperature during larval feeding period and prepupal period, 24°C.; illumination, 26 f. c.

conducted using various "day" lengths in which the ratio of hours of light to hours of darkness was kept at one to one. Results are shown in Table IX.

It is apparent from these results that the ratio of hours of light to hours of darkness is not enough to explain the method of operation of the photoperiod. Although the ratio was kept at one to one, diapause was induced in half or more of the larvae only in a comparatively narrow range of "day" lengths, namely, 20 to 26 hours. The absolute lengths of the periods of light and of darkness are both of importance. As is shown in Table X, the use of 15 hours of light per "day" tends to prevent diapause, but by reducing the dark period from 15 hours to

11 or 12 hours, it is possible to induce some diapause. The same table shows the results of experiments using 12-hour periods of light or of darkness. It is apparent that neither, by itself, is able to induce diapause; each must be combined with the appropriate period of light or darkness, as the case may be. Table X also gives the results of experiments using 9-hour periods of light or of darkness. It will be noted that whenever a period of darkness of only 9 hours was used, little or no diapause was induced. Apparently, diapause is induced only if a period

TABLE X

EFFECT OF VARIOUS COMBINATIONS OF LIGHT AND DARKNESS PER "DAY," DURING THE LARVAL FEEDING PERIOD, ON THE PERCENTAGE OF LARVAE ENTERING DIAPAUSE\*

HOURS PER "DAY" OF		TOTAL LARVAE	LARVAE ENTERING DIAPAUSE		
Light	Darkness		Number	Per Cent	Unweighted Mean Per Cent
15	15	185	4	2.2	1.4
15	15	143	1	0.7	
15	12	425	51	12.0	
15	12	321	134	41.7	28.5
15	12	274	87	31.7	
15	11	216	55	25.5	
15	11	220	60	27.3	26.4
15	9	63	0	0.0	
15	9	84	0	0.0	
12	15	201	156	77.6	72.1
12	15	192	128	66.7	
12	12	364	364	100.0	
12	12	381	371	97.4	98.7
12	9	128	2	1.6	
12	9	177	0	0.0	
9	15	127	76	59.8	66.2
9	15	175	127	72.6	
9	12	180	178	98.9	
9	12	292	290	99.3	99.4
9	12	156	156	100.0	
9	9	101	4	4.0	
9	9	206	4	1.9	2.9

\*Temperature, during larval feeding period and prepupal period, 24°C.; illumination, 26 f. c.

of at least 11 hours of darkness per "day" is used. The only exception to this is the experiment using 10 hours light and 10 hours darkness (Table IX).

A series of experiments was conducted using 11 hours of darkness per "day" with various periods of illumination. Results (Table XI) show that as the number of hours of light per day is increased to more than 13 the proportion of diapause is progressively decreased.

From the results shown in Tables IX to XI, it is apparent that for the induction of an appreciable percentage of diapause, the larvae must



be exposed during the feeding period to not less than 10 (usually 11) not more than 15 hours of darkness per day, and to not less than 8 nor more than 15 hours of light per day. The results of all experiments on photoperiod during the larval feeding period, at 24° C., are presented in figure 3. This figure shows the rather sharp dividing line at about 11 hours of darkness per day; it also shows that practically complete diapause is induced only under a rather narrow range of conditions. These data indicate that diapause in the oriental fruit moth larva is induced by a hormone or hormone-like substance that is produced by the larva during the larval feeding period. They further indicate that this hormone is produced by a two-phase reaction, which requires

TABLE XI

EFFECT OF 11 HOURS DARKNESS AND VARIOUS PERIODS OF LIGHT PER "DAY,"  
DURING LARVAL FEEDING PERIOD, ON THE PERCENTAGE OF ORIENTAL  
FRUIT MOTH LARVAE ENTERING DIAPAUSE\*

HOURS PER "DAY" OF		TOTAL LARVAE	LARVAE ENTERING DIAPAUSE		
Light	Darkness		Number	Per Cent	Unweighted Mean Per Cent
16	11	129	1	0.8	2.6
16	11	136	6	4.4	
15	11	216	55	25.5	
15	11	220	60	27.3	26.4
14	11	98	48	49.0	
14	11	124	66	53.2	
13	11	247	238	96.4	51.1
13	11	63	61	96.8	
13	11	64	62	96.9	
11	11	129	127	98.4	96.7
11	11	107	106	99.1	
8	11	143	142	99.3	
8	11	206	203	98.5	98.9
6	11	103	11	10.7	
6	11	107	12	11.2	

\*Temperature during larval feeding period and prepupal period, 24°C.; illumination, 26 f. c.

darkness for one phase and light for the other, as does photosynthesis. The darkness-induced phase is extremely sensitive to the length of the period of darkness and does not reach its effective point unless there are at least 11 hours of darkness per "day."

It is apparent that in the field in the late summer the onset of diapause is caused both by the decrease in the hours of light and by the corresponding increase in the hours of darkness, but that the rather rapid increase in percentage of diapause is caused mainly by the fact that the number of hours of darkness passes the critical minimum point for the induction of diapause at this time.

*Interruption of the Photoperiod.*—In the experiments reported so far, the periods of light and of darkness used were uninterrupted. Two

series of experiments were conducted to determine the effect of interrupting the period of light or of darkness. The results obtained by interrupting the period of light are shown in Table XII. Some decrease in the incidence of diapause was obtained by the use of 1 hour of darkness to interrupt the period of light. The first experiment in which the light period was interrupted by 2 hours of darkness is included only to

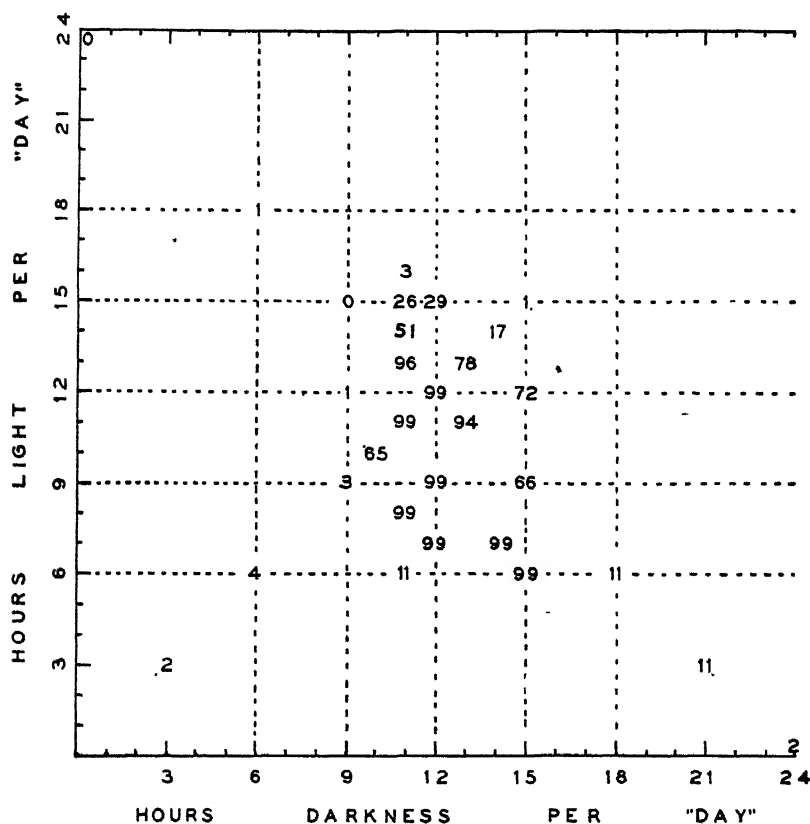


FIG. 3. Mean percentages of oriental fruit moth larvae entering diapause when exposed to various combinations of light and darkness per "day" during the larval feeding period. Temperature during larval feeding period and prepupal period, 24° C.; illumination, 26 f. c.

show a mistake: by reducing the main period of darkness to 10 hours, the induction of diapause was prevented. It was therefore necessary to repeat this experiment with the period of darkness increased to 11 hours. When this was done, it was shown that the effect of interrupting the period of light by 2 hours was to reduce the larval diapause by about one-third.

Results of the experiments on the interruption of the period of darkness (Table XIII) are similar to those obtained by interrupting

TABLE XII

EFFECT OF INTERRUPTING THE PERIOD OF LIGHT EACH "DAY" DURING THE LARVAL FEEDING PERIOD ON THE PERCENTAGE OF ORIENTAL FRUIT MOTH LARVAE ENTERING DIAPAUSE\*

HOURS PER "DAY"					TOTAL LARVAE	LARVAE ENTERING DIAPAUSE		
Light	Darkness	Light	Darkness	Total		Number	Per Cent	Unweighted Mean Per Cent
12	12	.....	.....	24	364	364	100.0	98.7
12	12	.....	.....	24	381	371	97.4	
6	1	6	11	24	202	188	93.1	92.8
6	1	6	11	24	204	189	92.6	
6	2	6	10	24	73	1	1.4	1.1
6	2	6	10	24	129	1	0.8	
6	2	6	11	25	271	176	64.9	62.3
6	2	6	11	25	206	123	59.7	
6	3	6	11	26	91	2	2.2	3.0
6	3	6	11	26	80	3	3.7	
6	6	6	6	24	89	5	5.6	4.0
6	6	6	6	24	82	2	2.4	

\*Temperature during larval feeding period and prepupal period, 24°C.; illumination, 26 f. c.

TABLE XIII

EFFECT OF INTERRUPTING THE PERIOD OF DARKNESS EACH DAY DURING THE LARVAL FEEDING PERIOD ON THE PERCENTAGE OF ORIENTAL FRUIT MOTH ENTERING DIAPAUSE\*

HOURS PER DAY				TOTAL LARVAE	LARVAE ENTERING DIAPAUSE		
Light	Darkness	Light	Darkness		Number	Per Cent	Unweighted Mean Per Cent
12	12	.....	.....	364	364	100.0	98.7
12	12	.....	.....	381	371	97.4	
11 $\frac{3}{4}$	6	$\frac{1}{4}$	6	38	38	100.0	100.0
11 $\frac{3}{4}$	6	$\frac{1}{4}$	6	90	90	100.0	
11	6	1	6	204	169	82.8	81.0
11	6	1	6	232	184	79.3	
10	6	2	6	107	51	47.7	55.2
10	6	2	6	86	54	62.8	
9	6	3	6	145	1	0.7	0.3
9	6	3	6	110	0	0.0	
6	6	6	6	89	5	5.6	4.0
6	6	6	6	82	2	2.4	

\*Temperature during larval feeding period and prepupal period, 24°C.; illumination, 26 f. c.

the period of illumination, except that the effect was slightly more pronounced. Oriental fruit moth larvae are much less sensitive to interruption of the dark period than are certain plants. Parker *et al.*

(1946) showed that in soybean and cocklebur the production of the flower primordia could be prevented by interrupting the period of darkness by only a few seconds at the proper illumination. With larvae of the oriental fruit moth, an interruption of two hours was required to reduce the incidence of diapause by one half.

TABLE XIV

EFFECT OF VARIOUS TEMPERATURES DURING THE PREPUPAL PERIOD ON THE PERCENTAGE OF ORIENTAL FRUIT MOTH LARVAE ENTERING DIAPAUSE OR QUIESCENCE

PHOTOPERIOD DURING LARVAL FEEDING*		TEMPERA- TURE DURING PREPUPAL PERIOD, DEGREES C.	TOTAL LARVAE	LARVAE ENTERING DIAPAUSE OR QUIESCENCE		
Hours Light Per Day	Hours Darkness Per Day			Number	Per Cent	Unweighted Mean Per Cent
Temperature during Larval Feeding, 12°C.						
12	12	30	49	1	2.0	3.3
12	12	30	43	2	4.7	
12	12	24	49	1	2.0	2.4
12	12	24	34	1	2.9	
12	12	12	52	51	98.1	99.0
12	12	12	65	65	100.0	
12	12	12†	50	5	10.0	11.3
12	12	12†	63	8	12.7	
15	9	24	39	1	2.6	1.3
15	9	24	51	0	0.0	
15	9	12	52	29	55.8	59.4
15	9	12	65	41	63.1	
15	9	12†	8	0	0.0	1.3
15	9	12†	38	1	2.6	
Temperature during Larval Feeding, 24°C.						
15	9	30	21	0	0.0	0.0
15	9	30	39	0	0.0	
15	9	24	63	0	0.0	0.0
15	9	24	84	0	0.0	
15	9	12	42	10	23.8	31.1
15	9	12	26	10	38.5	
15	9	12†	42	1	2.4	1.2
15	9	12†	25	0	0.0	

\*Illumination, 26 f. c.

†Temperature, 12°C. for 30 days; then 24°C.

These data again show that the production of the diapause factor or hormone is not dependent on the simple ratio of hours of light to hours of darkness, but is controlled by the absolute lengths of the periods of light and darkness.

*Effect of Temperature During the Prepupal Period.*—All the data previously shown (Tables II to XIII, inclusive) were from experiments

with insects held at 24° C. during the prepupal period, except for a few held at 21° C. Certain other larvae were held at 12° and 30° C. during the prepupal period in order to determine the effect of high and low temperatures at this stage of the life cycle. Results are shown in Tables XIV and XV.

TABLE XV

EFFECT OF VARIOUS TEMPERATURES DURING THE PREPUPAL PERIOD ON THE PERCENTAGE OF ORIENTAL FRUIT MOTH LARVAE ENTERING DIAPAUSE OR QUIESCENCE. TEMPERATURE DURING LARVAL FEEDING, 30°C.

PHOTOPERIOD DURING LARVAL FEEDING*		TEMPERA- TURE DURING PREPUPAL PERIOD, DEGREES C.	TOTAL LARVAE	LARVAE ENTERING DIAPAUSE OR QUIESCENCE		
Hours Light Per Day	Hours Darkness Per Day			Number	Per Cent	Unweighted Mean Per Cent
9	15	30	38	0	0.0	0.0
9	15	30	50	0	0.0	
9	15	24	44	0	0.0	
9	15	24	39	0	0.0	0.0
9	15	12	48	13	27.1	
9	15	12	44	9	20.5	23.8
9	15	12†	48	2	4.2	2.1
9	15	12†	44	0	0.0	
12	12	30	38	1	2.7	1.5
12	12	30	99	1	1.0	
12	12	30	134	1	0.7	
12	12	24	37	0	0.0	1.4
12	12	24	93	3	3.2	
12	12	24	199	2	1.0	
12	12	12	46	24	52.2	37.3
12	12	12	94	34	36.3	
12	12	12	94	22	23.4	
12	12	12†	45	2	4.4	3.4
12	12	12†	84	2	2.4	
12	12	12†	88	3	3.4	
15	9	30	46	0	0.0	0.0
15	9	30	31	0	0.0	
15	9	24	50	0	0.0	0.0
15	9	24	46	0	0.0	
15	9	12	27	8	29.6	31.1
15	9	12	43	14	32.6	
15	9	12†	27	0	0.0	0.0
15	9	12†	43	0	0.0	

\*Illumination, 26 f. c.

†Temperature, 12°C. for 30 days; then 24°C.

It should be remembered in reading Tables XIV and XV that larvae grown at 12° and 30° C. did not exhibit true diapause even when grown under a photoperiod that induced diapause at medium temperatures. No differences are shown between the larvae held at 30° C. and those held at 24° C. When held at 12° C. during the prepupal period, pupation was greatly delayed, but about the same pupation pattern was shown as

at higher temperatures, so that pupation was apparently complete after about 30 days. If these larvae were then moved to 24° C., many of those that had not pupated at the lower temperature did so in the course of the next week. This showed that many of the larvae that did not pupate in the expected time at 12° C. were not actually in diapause but only temporarily arrested in development.

It is well known that the full-fed larvae of the oriental fruit moth may be stored for several months at 1° C. without pupation. The effect of holding the larvae at 12° C. was similar. Some of the larvae pupated, but the others were quiescent. This state of quiescence, due to cold, resembles diapause, except that it is nonpersistent and development is resumed as soon as the insects are warmed; whereas diapause, once started, must run its course.

As is shown in Table XIV, those larvae which had been fed at 12° C. were quite prone to remain quiescent when held at the same temperature during the prepupal period. They showed a sensitivity to cold in the

TABLE XVI

EFFECT OF VARIOUS HUMIDITIES DURING THE PREPUPAL PERIOD ON THE PERCENTAGE OF ORIENTAL FRUIT MOTH LARVAE ENTERING DIAPAUSE\*

PER CENT RELATIVE HUMIDITY	TOTAL LARVAE	LARVAE ENTERING DIAPAUSE	
		Number	Per Cent
0	50	1	2.0
50	114	1	0.9
100	35	0	0.0

\*Temperature during larval feeding period, 30°C.; daily photoperiod, 12 hours; temperature during prepupal period, 24°C.

matter of the induction of quiescence when compared with larvae grown at higher temperatures. It may be that this result was obtained because larvae grown at 12° C. had not begun the first part of the changes leading to pupation before emergence, as may have been the case with larvae grown at higher temperatures. Larvae completing development in the field during the winter may delay their emergence until spring because of this sensitivity to the induction of quiescence by cold, even though they did not enter a state of true diapause. Cousin (1932) recorded a similar effect in *Lucilia sericata*, and stated that those larvae which were grown at low temperatures were more readily stored at low temperatures.

*Effect of Humidity During the Prepupal Period.*—Mainly because Cousin (1932) reported that *Lucilia* larvae stored in either saturated or desiccated air failed to pupate, an experiment was conducted to test this on oriental fruit moth larvae. A batch of larvae grown at 30° C., with a 12-hour photoperiod, was divided into three lots. One lot was held at 50 per cent relative humidity; the second lot was placed in a tight jar over anhydrous calcium chloride, which reduced the relative humidity to practically zero per cent; and the third lot was placed in

another tight jar over wet sand, which saturated the air. As shown in Table XVI, there were no differences between the lots. No diapause or arrest of development was induced.

*Miscellaneous Observations.*—It was noticed early in the work that in any experiment in which only a part of the larvae entered diapause, those larvae which emerged from the fruit early were less likely to enter diapause than those which emerged later. An example of this is shown in Table XVII. Apparently, those larvae which will enter diapause feed a little longer, on the average, than those which will not.

Larvae grown under conditions that induce very little diapause pupate promptly, the pupation occurring over a comparatively short period. With larvae grown under conditions that induce considerable diapause, however, the pupation period is protracted, stragglers pupating over a rather extended period. This suggests that there is a balance

TABLE XVII

RELATION BETWEEN LENGTH OF LARVAL FEEDING PERIOD AND PERCENTAGE OF ORIENTAL FRUIT MOTH LARVAE ENTERING DIAPAUSE\*

LENGTH OF LARVAL FEEDING PERIOD, IN DAYS	EXPERIMENT 28		EXPERIMENT 29		EXPERIMENT 30		MEAN PER CENT LARVAE ENTERING DIAPAUSE
	Total Larvae	Per Cent Diapause	Total Larvae	Per Cent Diapause	Total Larvae	Per Cent Diapause	
12	4	0.0	13	0.0	10	10.0	3.3
13	37	0.0	53	24.5	63	15.9	13.5
14	116	2.6	91	44.0	76	28.9	25.2
15	151	14.6	64	50.0	46	32.6	32.4
16	66	25.8	60	56.7	40	45.0	42.5
17	35	14.3	27	44.4	22	45.5	34.7
18	16	25.0	13	23.1	17	64.7	37.6

\*Temperature during larval feeding period, 24°C.; 15 hours light and 12 hours darkness per "day"; illumination, 26 f. c. Temperature during prepupal period, 24°C.

within the insect, and that under these conditions certain individuals are "on the fence," the factors pushing them toward immediate pupation just about equaling the factors pushing them toward diapause.

The duration of the period that oriental fruit moth larvae remain in diapause, once they have entered, is determined by the temperature at which they are held. The higher the temperature, the shorter the period of inactivity. At 26° C. they emerge from diapause in about two months. Exposure to low temperature appears to have no tendency to break the diapause, its only effect being to prolong the period that the larvae remain in that state.

*Discussion.*—Length of day plays the dominant role in determining which individuals of the oriental fruit moth will enter diapause. It is possible to grow this species indefinitely without the intervention of diapause by using a photoperiod either too long or too short to induce it. The potentiality of diapause always remains, however, since diapause

occurs when any larvae are exposed to the proper conditions during the larval feeding period.

The induction of diapause appears to be caused by a hormone produced during the larval feeding period in response to the proper photoperiod at medium temperatures. This hormone apparently is produced by a two-phase reaction, one phase of which goes on in the dark, and the other in the light. The darkness-induced phase of the reaction must continue for about 11 hours each day before it is sufficiently complete to allow the production of the hormone; and, similarly, the light-induced phase of the reaction must continue for about 7 hours. There is also a maximum limit for each phase of the reaction, that for the darkness-induced phase being about 16 hours and that for the light-induced phase being between 16 and 18 hours.

It seems probable that this diapause-inducing factor acts only to induce diapause, not to control it after its induction. Once diapause has been started, it must run its course, and the amount of the hormone which caused its onset does not appear to affect its normal course.

The question has been raised whether the effect of the photoperiod on the larvae may not be secondary, that is, caused by a hormone produced in the fruit and taken up by the larvae in feeding, rather than by a hormone produced in the larvae. It has not been possible to grow either the oriental fruit moth or the codling moth on any non-living medium, which would have settled this point. Three considerations point to the primary nature of the effect: (1) The fruit is not opaque; light passes through it reasonably well and so reaches the insect feeding inside. (2) So far as is known, the production of photoperiodically induced hormones in plants is in the leaves, and all experiments reported here were with excised fruits. (3) Plant hormones are ordinarily rather persistent, but results obtained in this work showed no influence from the photoperiod to which the fruits had been exposed before their infestation.

#### *The codling moth*

The codling moth, *Carpocapsa pomonella* (L.), is closely related to the oriental fruit moth and is similar to it in life history and habits. Individuals of this species also enter diapause in the late summer or fall and pass the winter as full-fed larvae. The main difference between the codling moth and the oriental fruit moth in regard to diapause is that the codling moth produces hibernants in appreciable numbers during the summer.

Only enough experiments were conducted to show that the same principles hold for the codling moth as for the oriental fruit moth. Table XVIII shows the effect of the photoperiod on the percentage of codling moth larvae entering diapause. By comparing this table with Table II, it may be seen that the results are similar, the difference being that at 14 hours light and 10 hours darkness per day a considerably larger percentage of the codling moth larvae entered diapause. The two species react the same to 15 hours light per day.

Experiments were also conducted to determine the effect of growing the codling moth larvae at 12° and 30° C. Results were similar to those obtained with the oriental fruit moth, except that at 12 hours light



per day and 30° C. about three-fourths of the codling moth larvae entered diapause. It appears that either a higher temperature or a longer photoperiod is required to prevent diapause in the codling moth than in the oriental fruit moth.

### *The greenbottle fly*

A great deal of work on diapause has been done with the greenbottle fly, *Lucilia sericata* Meig. It was decided to investigate this species, incidentally, partly as a check on the earlier work by Robaud (1922) and Cousin (1932), and partly in hope that the species would react to length of photoperiod and thus give us a species in which the photoperiodic effect could be shown to be definitely primary. Results obtained showed that, although there is a considerable amount of true diapause in this species, the photoperiod has no effect. The percentage of larvae entering diapause was greatly increased by the use of low temperatures

TABLE XVIII

EFFECT OF NUMBER OF HOURS OF LIGHT PER DAY DURING LARVAL FEEDING PERIOD ON THE PERCENTAGE OF CODLING MOTH LARVAE ENTERING DIAPAUSE\*

HOURS PER DAY OF		TOTAL LARVAE	LARVAE ENTERING DIAPAUSE	
Light	Darkness		Number	Per Cent
12	12	22	22	100.0
13	11	63	61	96.8
14	10	61	46	75.4
15	9	36	0	0.0

\*Temperature during larval feeding period and prepupal period, 24°C.; illumination, 26 f. c.

during the larval feeding period. Low temperatures during the prepupal period did not induce diapause, but only arrested development temporarily.

Cousin (1932) reported that the pupation of full-fed *Lucilia* larvae was prevented by holding them in closed containers at either 100 per cent or zero per cent relative humidity. These larvae died after a few days. We repeated this work with the addition of an experiment in which saturated fresh air was circulated through a container. The results obtained in the closed containers were similar to those reported by Cousin, but the larvae held at 100 per cent relative humidity with air circulation pupated normally. The prevention of pupation in the closed containers was apparently caused by the foulness of the confined air, which poisoned the larvae.

### *The vegetable weevil*

The vegetable weevil, *Listroderes obliquus* Klug, has only one generation per year. Adults pass the summer in diapause, hiding under trash on the ground, and do not develop eggs until fall. The

larvae feed through the winter, pupate, and emerge as adults in the spring.

An experiment was conducted to determine whether or not the length of the photoperiod affected entrance into diapause in this species. Larvae were grown under conditions of 9, 15, and 24 hours light per day. In all cases all the adults entered diapause, the length of the photoperiod having no effect on the induction of diapause. Apparently, the vegetable weevil enters diapause each generation, regardless of the conditions under which it is raised and held. Attempts were made to break the diapause in the adults by changing the photoperiod and by soaking them in water. Neither method was successful.

#### SUMMARY

Diapause is a physiological state of arrested development which enables an organism to survive more easily a period of unfavorable conditions.

It is possible to divide the insect species which enter diapause into the following groups:

1. Species which enter diapause each generation. It may be that any conditions which allow these insects to live and develop induce diapause.

2. Species which enter diapause only in response to certain stimuli. There may be several generations between periods of diapause, or, under the proper conditions, diapause may appear in each generation. Diapause may be induced by any factor in the environment or by any combination of factors. The factors most commonly involved are: (a) temperature, either high, medium, or low; (b) moisture, either atmospheric or in the food; (c) food, through its quantity, quality, or moisture content; and (d) photoperiod.

All these behavior patterns are inherited, and there are a few species in which some strains differ from others in their behavior patterns or in their sensitivity to environmental stimuli.

The induction of diapause in the oriental fruit moth is controlled by temperature and daily exposure to light during the larval feeding period. Larvae grown in the absence of light do not enter diapause. As the period of light per day is increased to more than 3 hours, the percentage of diapause increases, reaching 100 per cent with about 12 hours of light per day. As the photoperiod is increased to more than 13 hours per day, the percentage of diapause drops suddenly to practically zero, and remains at or near this point during further increases in light.

The photoperiodic effect on the induction of diapause in the oriental fruit moth is apparently caused by a hormone which is produced by a two-phase reaction during the larval feeding period. The light-induced phase requires not less than 7 nor more than 15 hours per day, and the darkness-induced phase requires not less than 11 nor more than 16 hours per day, to bring the reaction to a successful conclusion.

Diapause is induced only at medium temperatures. Either high or low temperatures during larval feeding prevent its occurrence.

The codling moth, *Carpocapsa pomonella* (L.), enters diapause under the same conditions as does the oriental fruit moth, except that it

requires a slightly higher temperature or a slightly longer photoperiod to prevent diapause.

The greenbottle fly, *Lucilia sericata* Meig., enters diapause in response to low temperatures during the larval feeding period. The photoperiod has no effect.

The vegetable weevil, *Listroderes obliquus* Klug, has only one generation each year and apparently enters diapause in each generation.

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WHAT BUTTERFLY IS IT?, by ANNA PISTORIUS. 25 pages. Wilcox and Follett Co., Chicago. 1949. Price, \$1.25.

This is something more than an ordinary children's book (if the term "ordinary" can be applied to children's books of today); it has some usefulness for the beginning leopdopterist. Fifty-three butterflies (the cover advertisement says fifty-four) are illustrated in color, with some condensed, simply and interestingly written information concerning each of them. One might take exception to certain statements in the book, for example, the implication that the monarch occurs earlier in the season than the mourning cloak, or the answer to the question, "What butterfly worries farmers?" (Why not the cabbage butterfly, rather than the hop merchant?) Nevertheless, the book, with its quiz-game style, its attractive appearance, and the apparent accuracy of the natural-size illustrations, should, in addition to its entertainment value, inspire appreciation and create new interests among young nature students. Entomology needs to be advertised favorably, and one way to do this is to place such works as this in the hands of children.—M. T. J.

## NEW SPECIES OF SIMULIIDAE (DIPTERA) FROM GUATEMALA. I.<sup>1</sup>

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In the course of entomological investigations concerning the Simuliidae of Guatemala and their possible role in the transmission of onchocerciasis, several described species of this family, hitherto unknown from Guatemala, as well as a number of completely new species, have been found to exist there. This paper presents descriptions of three new species with notes on their distribution and ecology. It is expected that in future works by this author there will be included lists of all species found in Guatemala, descriptions of other new species, descriptions of apparently unknown stages of already described species, and distributional and ecological data about each.

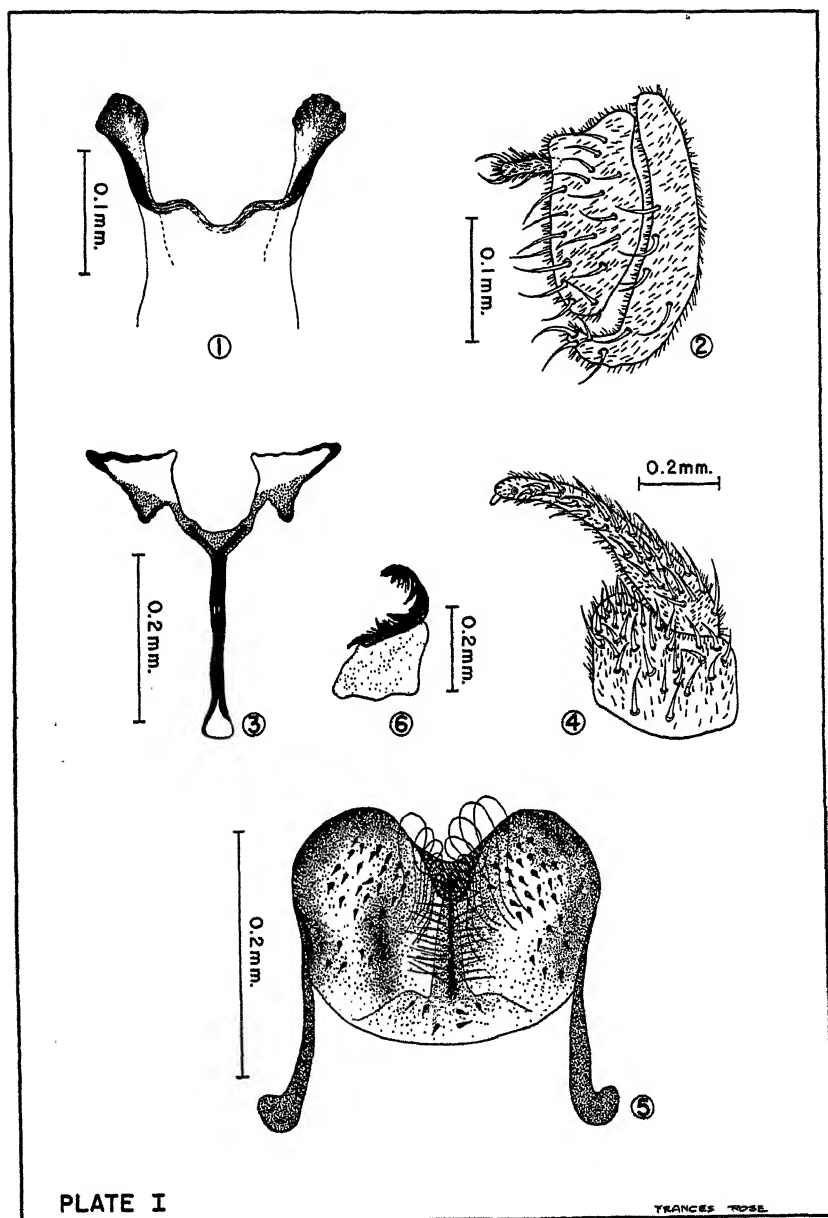
### *Simulium (Simulium) microbranchium*, new species

*Female*.—3.1 mm. long.

Head: Dichoptic. Antennae short (0.5 mm.), tapering, deeply inserted into head capsule, with 11 segments; basal two segments rust-brown, the others black; apical margin of each segment with fringe of minute, white, scale-like hairs; third segment very slightly longer than second, 0.8 times as long as the fourth and fifth segments measured together. Palpi black. Frons, clypeus, and occipital region black, covered with greyish-white pruinosity and fine, black hairs. Fronto-ocular triangle 60  $\mu$  long, 72  $\mu$  at base; black. Bucco-pharyngeal apparatus with no teeth but with bulb-like dilatations along margin of lateral processes; border of median space thickened and slightly sclerotized (fig. 1).

Thorax: Mesonotum black; when viewed from above, with the head directed toward the observer and the source of light coming from in front at a 45° angle to the surface, there are seen on either side of the midline an isolated, narrow, longitudinal band of silver pruinosity, one-half the length of the mesonotum, and two silvery pruinose triangles, one in the humeral angle and the other anterior to the longitudinal band but not contiguous with it; short, narrow, appressed, bronze-colored scales sparsely, but rather evenly distributed

<sup>1</sup>The studies and observations on which this article is based were conducted with the support of the Laboratory of Tropical Diseases of the National Institutes of Health, U. S. Public Health Service, under the sponsorship of the Pan American Sanitary Bureau in cooperation with the Dirección General de Sanidad Pública of the Republic of Guatemala. The investigation was aided by a research grant from the Division of Research Grants and Fellowships of the National Institutes of Health. Costs of publication have been paid by the Pan American Sanitary Bureau.



*Simulium* (*Simulium*) *microbranchium*, n. sp. FIG. 1. Bucco-pharyngeal apparatus. FIG. 2. Cercus and anal lobe of female. FIG. 3. Genital fork of female. FIG. 4. Sidepiece and clasper of male (ventral view). FIG. 5. Adminiculum of male (ventral view). FIG. 6. Adminicular arm and lateral plate.

over anterior third of mesonotum, and extending backward to the half-way mark along the lateral margins; posterior, depressed region more heavily clothed by similar, but longer scales and by long, fine, black hairs; entire mesonotum covered with minute, short, black hairs, so short that they are noticed only with higher magnifications of the dissecting microscope; humeral corners with dense fringe of long yellow hairs. Scutellum reddish-brown, clothed with numerous long, yellow, appressed scales and with long, fine, black hairs. Postnotum black with large, centrally located group of yellow appressed scales. Pleural region evenly grey-white pruinose. Wings, 3.6 mm. long, without discal cell; subcostal vein pilose along its entire length; radius haired only along distal half;  $r_{2+3}$  and  $r_{4+5}$  fused almost until their union with the costa; stem and knob of halteres white.

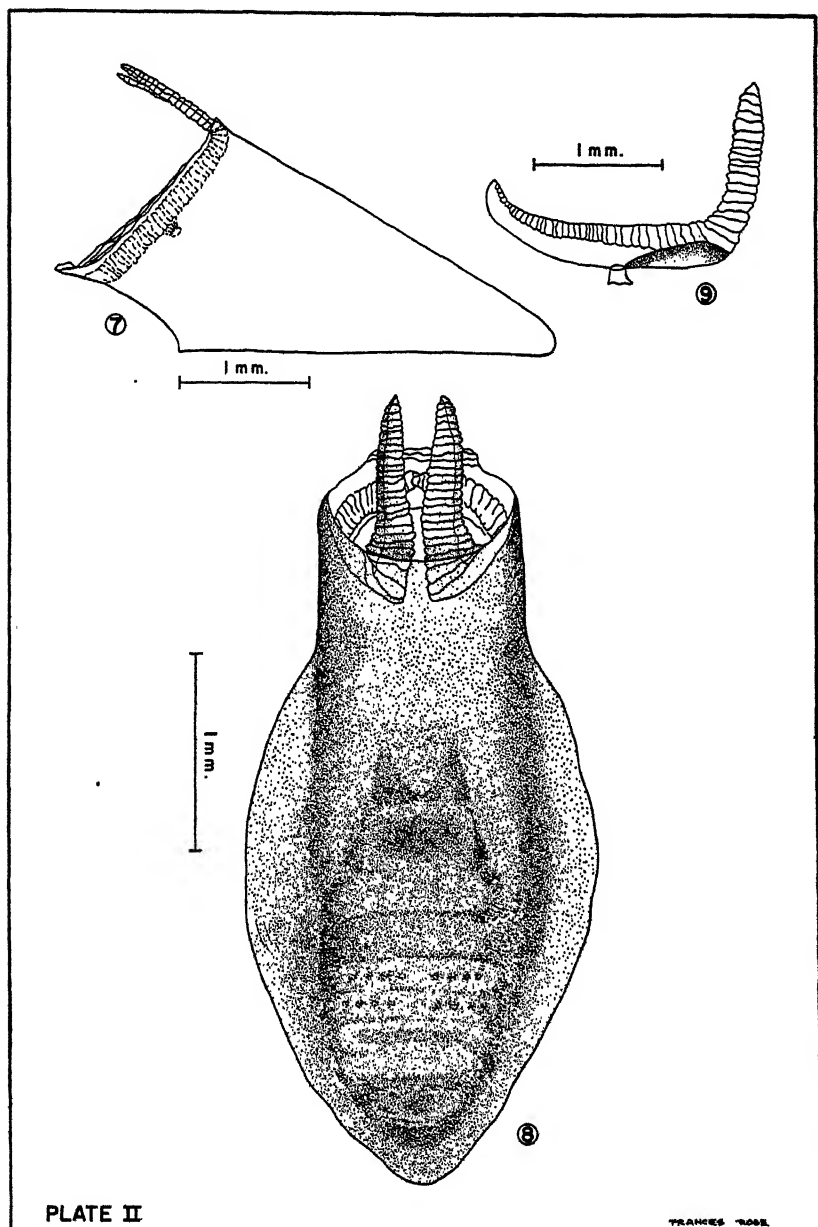
Legs: All coxae dark brown, all trochanters yellow. Leg 1—Length, 3.4 mm.; femur and basal four-fifths of tibia yellow; apical fifth of tibia, and all of tarsus black. Leg 2—Length, 3.0 mm.; femur yellow; tibia yellow along basal three-fourths, apical fourth dark brown; basitarsus yellow along proximal half, the distal half, as well as all other tarsal segments, dark brown. Leg 3—Length, 3.7 mm.; femur yellow except for very small patch at distal extremity; tibia with same color pattern as femur; basitarsus pale yellow except along proximal half of dorsal face where it is brown; calcipala short but distinctly formed; pedisulcus very deep; second through fifth tarsal segments dark brown; claw with sub-basal tooth.

Abdomen: Dull brownish-black with only the tergite of the first segment and the pleurites of the second segment silvery-white pruinose. First tergite with irregular row of short, black hairs and each pleurite of the same segment with cluster of very long black hairs. Sternites grey-pruinose.

Genitalia: Cercus irregularly quadrangular, with finger-like projection extending backward from inner side near the upper margin; hairs of projection dense and black. Anal lobe sausage-shaped, the ventral end extending posteriorly beneath the cercus (fig. 2). Genital rod narrow, branching rather sharply to form two arms; expansions of the arms triangular, very slightly sclerotized (fig. 3).

*Male*.—This specimen was taken from its pupal skin after natural emergence failed. Its state precluded the possibility of describing more than the genitalia.

Genitalia: Sidepiece wider than long. Clasper long and narrow, 2.2 times as long as the sidepiece, with strong spine at apex (fig. 4). Adminiculum wider than long with broad, heavily sclerotized basal pieces; both "wings" of adminicular plate with central longitudinal depression on ventral side; ventral surface of adminiculum clothed with minute spines, more numerous toward apical end; center of apical margin of adminiculum indented and overlaid with a lappet which extends from a thin plate on the dorsal side around to the ventral surface where it continues proximad in the form of a heavier tongue; along the entire margin of this tongue arises a row of very long, curled hairs which extend posteriorly; the entire central portion of the adminiculum, extending from the apex to almost the posterior margin, is raised in the form of a keel, less pronounced over the tongue of the lappet where it



*Simulium (Simulium) microbranchium*, n. sp. FIG. 7. Cocoon (in profile).  
FIG. 8. Cocoon with enclosed pupa (dorsal view). FIG. 9. Pupal filament (right side).



seems to arise, and gradually becoming higher and broader toward its posterior limit; near the posterior margin of the adminicular plate the keel again seems to flatten out until it appears to blend into the plate itself; there is a longitudinal row of shorter, more spine-like hairs on each side of the crest of the keel (fig. 5); arms of adminiculum with two blunt spines at the apical end and four longer spines, intermingled with numerous hairs, evenly spaced along the remainder of its length; lateral plate triangular and hyaline (fig. 6).

*Pupa*.—Cocoon: Length along dorsal slope, 3.2 mm.; width at widest point, 2.9 mm.; length of collar, 0.8 mm.

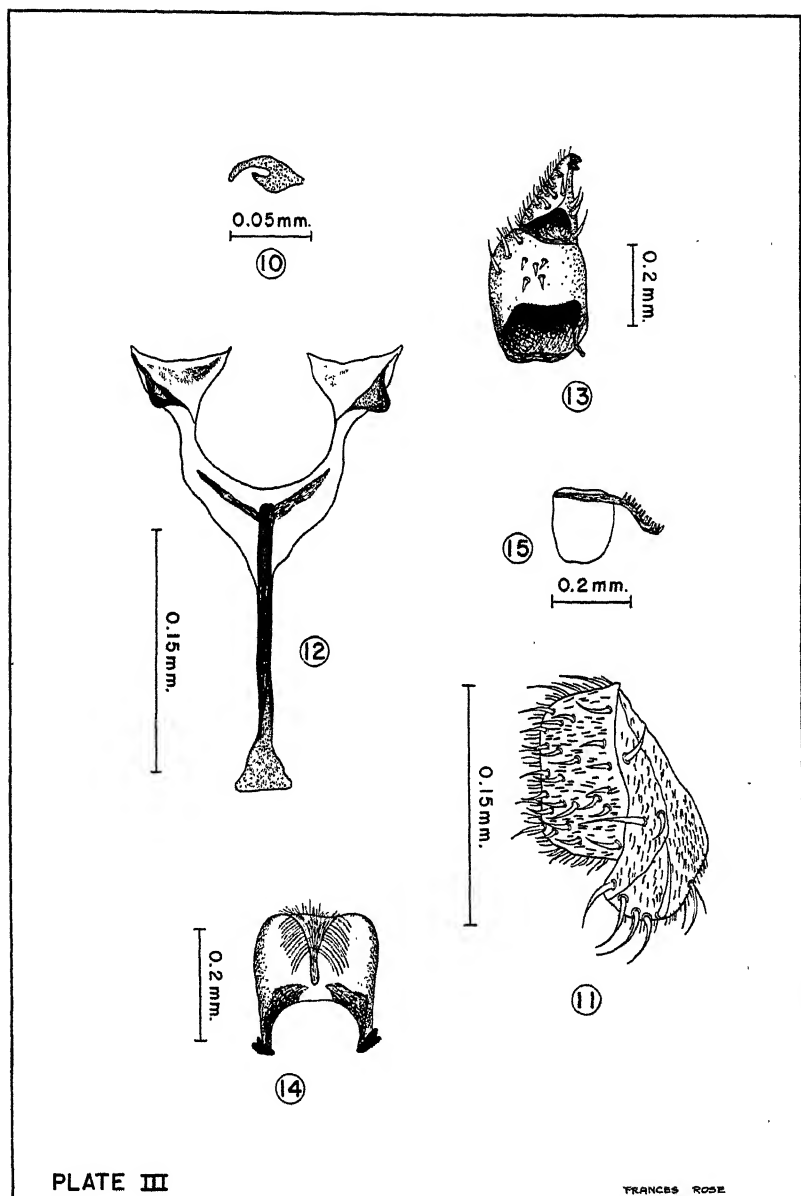
The cocoon is slipper-shaped with a prominent collar (fig. 7); in dorsal view, extensions of the case are seen to slope laterad and basad to form wing-like structures (fig. 8); rim around anterior aperture of cocoon irregular, appearing thicker than rest of cocoon; base woven along posterior half only.

Filaments: Dorsal, 1.1 mm. in length, 0.22 mm. in width; ventro-lateral, 1.8 mm. in length, 0.33 mm. in width.

The respiratory filaments are horn-like when viewed along their broad aspect (fig. 8). The apparatus of each side is in the form of a broad "V," the two arms being so curved that the broad surfaces are at an angle of 90° to each other (fig. 9). The filaments are so thin that unless they are carefully dissected from the cocoon the ventral element may go unnoticed. The dorsal arm extends anteriorly from the cocoon for only 0.8 mm. When viewed from above with the aid of only a hand lens, this element is hardly visible. The lateroventral arm, which is a gentle continuation of the dorsal arm, curves around the collar near the anterior aperture and remains contiguous with it along its entire extent, except at its distal extremity where it overlaps with the corresponding arm of the opposite side. Halfway along its length is found the only attachment to the pupal body, and along its entire mesoventral surface, between the attachment and the apex of the "V," there is a rather deep groove.

The horn-like pupal filaments of this species place it in the group along with *deleoni* Vargas (3), *capricornis* de León (2), *canadense* Hearle (1 and 3), *estevezi* Vargas (3), and *ayrozai* Vargas (3). It differs from all of these by having the dorsal and lateroventral arms extremely thin, by the angle between the two arms being more obtuse, by the dorsal arms being extremely short and straight, and the ventral arms being very closely associated with the collar of the cocoon. The species is being named *microbranchium* because of the very small size of the dorsal arms of the respiratory apparatus in relation to the length of the cocoon.

*Ecological Notes*.—*Simulium* (S.) *microbranchium* has been found in Guatemala in the western departments of Sololá, Totonicapán, Quiché, and Quezaltenango (near the dividing line with Huehuetenango). The species apparently prefers the highlands, between altitudes from 5,000 to 7,500 feet. Collections were made entirely during the dry season in the months of November, December, and March. The streams in which this species were found breeding were all comparatively wide, ranging from 4 to 23 feet, with an average width of 11 feet and having a depth of from 6 inches to 3 feet, with an average of 16 inches. The



*Simulium (Eusimulium) aguirrei*, n. sp. FIG. 10. Claw of hind leg of female. FIG. 11. Cercus and anal lobe of female. FIG. 12. Genital fork of female. FIG. 13. Sidepiece and clasper of male (dorsal view). FIG. 14. Adminiculum of male (ventral view). FIG. 15. Adminicular arm and lateral plate.

temperature of the streams ranged from 8° C. to 14° C., with an average of 11° C.; the velocity of current, from 12 inches per second to that of a waterfall, the average current, excluding waterfall, 18 inches per second; the pH, from 6.6 to 7.4 with an average of 7.0. In almost all instances the collecting spots were well exposed to the sun. The substratum of the streams consisted of sand and mud, with large and small stones, and with few to many narrow-leaved emergent plants. The pupae of this species were found mainly on stones, but also on twigs and petioles. Other species encountered in the same streams were: *S. veracruzianum* Vargas, *wrightii* Vargas, *aureum* (Fries), *tricornis* de León, *downsi* Vargas, *jobbinsi* Vargas, *callidum* Dyar & Shannon, *ochraceum* Walker, *rubicundulum* Knab, *capricornis* de León, and two other species still undescribed.

*Types*.—*Holotype*, female (Accession 000-4); reared from pupa collected in the Río Los Arcos near Los Encuentros (Sololá, Guatemala) on November 4, 1948; collectors, Luis de la Torre and Herbert T. Dalmat; preserved on five slides of genitalia, legs, wing, head, and bucco-pharyngeal apparatus; cocoon and pupal case maintained in alcohol. *Allotype*, male (Accession I-23); formed adult taken from pupal skin and slides prepared of genitalia, legs, and pupal filaments; cocoon kept in alcohol; pupa collected in the Río Samalá, just beyond the town of Totonicapán (Totonicapán, Guatemala) on December 11, 1947; collectors, J. Onofre Ochoa A. and Herbert T. Dalmat. *Paratypes*, one female (5Y-5), its cocoon, and four pupae (5Y-10) collected December 15, 1948, by Adalberto Girón, Vicente Castellanos and J. Onofre Ochoa A. in a stream just beyond San Carlos Sija, between Quezaltenango and Huehuetenango; adult mounted on minuten nadeln, pupal case and cocoon, and the four pupae in alcohol. Four pupae (000-7) collected with holotype. One pupa (5V-5) collected in type locality on December 13, 1948, by Vicente Castellanos, J. Onofre Ochoa A. and Adalberto Girón. One pupa (6V-11) collected March 16, 1949, along the side of a small waterfall near Panajachel (Sololá, Guatemala); collectors, Adán Flores M. and Jaime Rosales G. Two pupae (I-23) collected along with allotype. One pupa (5T-1) collected by Vicente Castellanos, Adalberto Girón and J. Onofre Ochoa A., December 14, 1948, in the Río Micovez, near Nebaj (Quiché, Guatemala).

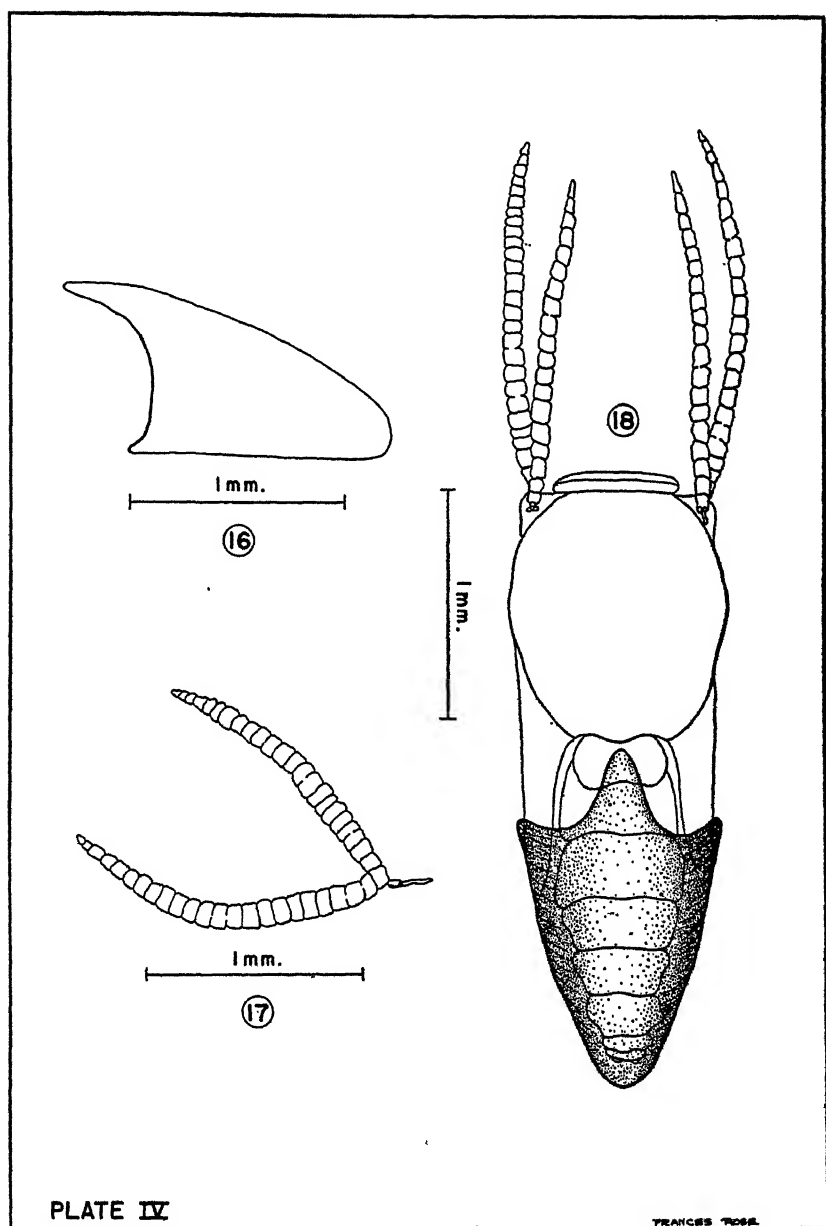
Holotype and allotype to be deposited in the collection of the United States National Museum. Paratypes in collection of the author.

### **Simulium (Eusimulium) aguirrei, new species**

*Female*.—Extracted from the pupal skin after natural emergence failed. The state of the specimen precludes a complete description.

*Head*: Dichoptic. Fronto-ocular triangle 100  $\mu$  high, 60  $\mu$  wide at base of triangle. Antennae with 11 segments, the third segment being one and one-third times as long as the second segment and two and one-fourth times as long as the fourth. Bucco-pharyngeal apparatus very simple, without teeth, only the lateral extremities sclerotized.

*Thorax*: Postnotum with two distinct groups of hairs. Hind basitarsus with definite calcipala; pedisulcus clearly marked. Claw narrow, with basal prolongation (fig. 10).



*Simulium (Eusimulium) aguirrei*, n. sp. FIG. 16. Cocoon (in profile). FIG. 17. Pupal filament. FIG. 18. Cocoon with enclosed pupa (dorsal view).

Genitalia: Cercus (fig. 11) quadrangular, 0.09 mm. in its longest dimension, posterior angles rounded; surface evenly covered by very small, fine hairs; setae sparsely, but evenly distributed throughout. Anal lobe (fig. 11) pointed dorsally, broadening toward the mid-section, and becoming bluntly rounded ventrally; 0.14 mm. long; surface covered with fine hairs, the same as those on the cercus; setae found only on posterior and ventral margins. Genital rod (fig. 12) greatly expanded at base; area from which genital arms branch from rod, broadly triangular and hyaline; space between arms rounded; apex of each arm expanded triangularly, the exterior angle formed by a sclerotized extension of the terminal plate.

According to Vargas and Diaz Nájera (5) the presence of calcipala, pedisulcus, and pilosity on the postnotum would place this species in the subgenus *Eusimulium*. This species then becomes the second in Guatemala to be included in this subgenus, the other being *S. (E.) aureum* (Fries).

*Male*.—Specimen also taken from pupal case. Only the genitalia are in a state considered satisfactory for description.

Genitalia: Sidepiece longer than wide, 1.4 times as long as the clasper. Clasper also longer than wide and with two very stout spines at its apical end (fig. 13). Adminiculum (fig. 14) slightly longer than broad with dorsal tongue and ventral concavity; basal processes stout and with their extremities heavily sclerotized; arm of adminiculum with small fine teeth, the lateral plate quadrangular and hyaline (fig. 15).

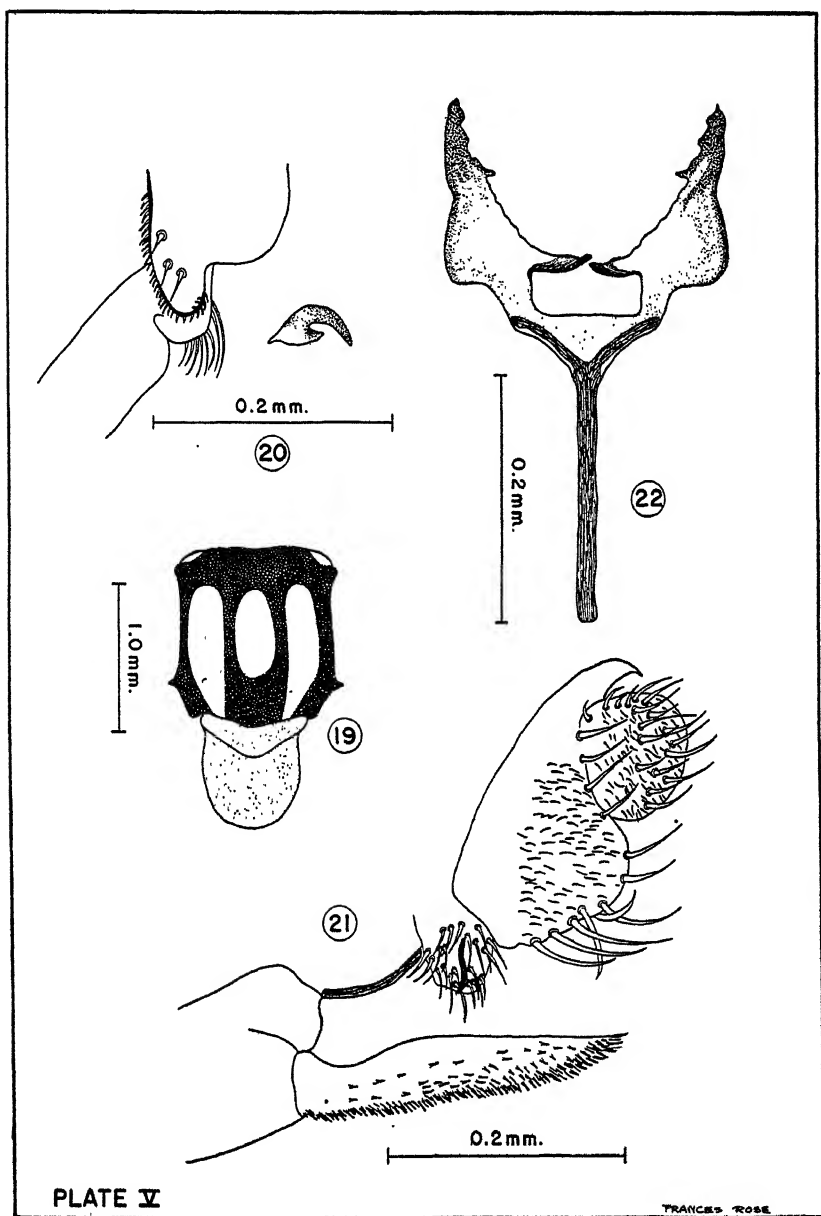
*Pupa*.—Cocoon: Length along the longest axis (including dorsal prolongation), 1.5 mm.; dorsal prolongation alone, 0.4 mm.; width at widest point, 0.9 mm.

The cocoon is of the wall-pocket type, having no collar between the anterior aperture and the substratum; rim around anterior aperture not thickened; dorsal margin extends anteriorly, tapering to almost a point; case rather coarsely woven with the floor complete along the posterior five-sixths (figs. 16 and 18).

Filaments: Length, 1.4 mm.; diameter, 0.1 mm. The breathing apparatus on each side consists of two long, tubular filaments which are so arched as to form a "V" with the arms convex on the outer surface when viewed from the side. These filaments have superficial transverse annulations along their entire length but have absolutely no branches (fig. 17).

This species is very easily distinguishable by virtue of the extremely short cocoon, encasing approximately one-half the pupa, and the simple, tubular filaments which almost equal the cocoon in length (fig. 18). Because of the tubular filaments it can be said that the pupa of *aguirrei* resembles that of *Cnephia grenieri* Vargas (5). However, the respiratory apparatus of *aguirrei* is distinct in having the filaments annulated and in being composed of only two branches rather than four.

*Ecological Notes*.—This species has been found only twice, both times on the Pacific slope of the Volcano Acatenango, near the town of San Bernabé Acatenango (Chimaltenango, Guatemala). It seems that the presence of this species is greatly affected by the presence of coffee pulp in the streams. When the pulp was dumped during the milling process, the species disappeared completely and no further specimens



*Simulium (Dyarella) yepocapense*, n. sp. FIG. 19. Color pattern of mesonotum of female. FIG. 20. Calcipala, pedisulcus, and claw of right hind leg of female. FIG. 21. Cercus, anal lobe, and ovipositor of female. FIG. 22. Genital fork of female.

have been found. The streams are at an altitude of approximately 4,000 feet and are well shaded by trees and shrubs. At the point of collection the streams were about 20 inches wide, three inches deep, flowed at a rate of five inches per second, had a temperature ranging from 18° C. to 22° C. and a pH of 7.1. In both streams the substratum was formed by sand and mud with many small and large stones, and with abundant emergent vegetation. One pupa was found on a stone, while the other was found on a narrow leaf. Other species found in the same streams are: *S. parrai* Vargas, *capricornis* de León, *tricornis* de León, *veracruzianum* Vargas, and *metallicum* Bellardi.

*Types*.—*Holotype*, female (Accession Acat. 15-20); taken from pupa which had been collected October 30, 1947, in the Río San Diego, Finca San Diego, Acatenango by Ruperto Cabrera and Daniel Luch; mounted on six slides, including head and bucco-pharyngeal apparatus, legs, wings, thorax showing the postnotum, genitalia, and pupal filaments. The cocoon, which is in bad condition, has been kept in alcohol. *Allotype*, male (Accession Acat. 241-13); taken from pupa collected July 14, 1948, in the Río Reposadera, Finca San Vicente Pacum, Acatenango by Carlos Santizo and Daniel Luch; mounted on five slides of the wings, legs, genitalia, thorax (macerated), and pupal filaments.

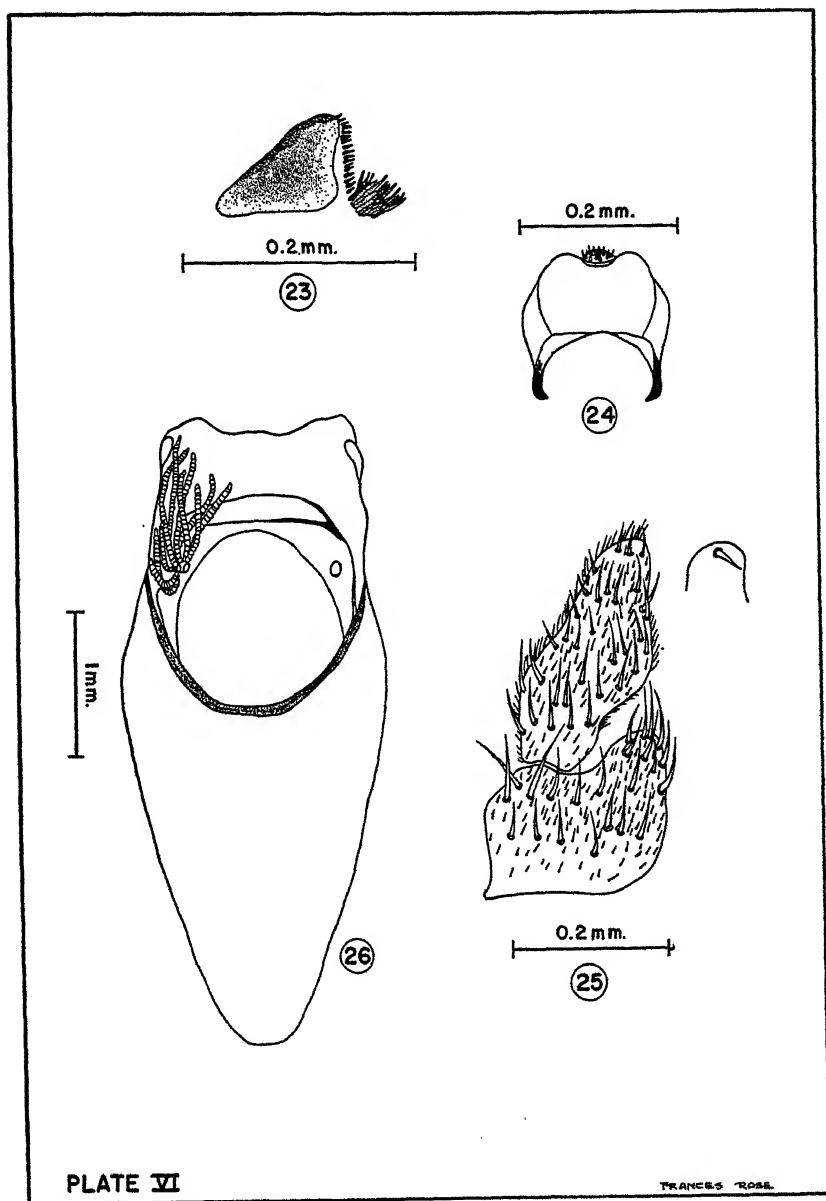
Both the holotype and allotype will be deposited in the collection of the United States National Museum. This species is named in honor of J. Onofre Ochoa Aguirre, who has been faithfully assisting the author in his entomological investigations.

### **Simulium (Dyarella) yepocapense, new species**

*Female*.—3.1 mm. long.

Head: Dichoptic. Fronto-ocular triangle 120  $\mu$  high, 60  $\mu$  wide at base. Antennae with 11 segments, first two yellowish-brown, the others black; first two segments very closely united, their length together being one and one-third as long as the third segment alone. Frons, clypeus, frontoocular triangle, and occipital region black, completely covered with silvery-white pruinosity. Hairs of occipital region and frontal hairs of fine texture, black; hairs of clypeus yellowish-white. Bucco-pharyngeal apparatus simple and well sclerotized along the entire arch, without teeth.

Thorax: Mesonotum rust-brown, with short, black, appressed hairs sparsely distributed throughout; when viewed from above, with the head directed forward and with light source from in front of a 45° angle to the specimen, there are three isolated, grey pruinose areas (fig. 19); narrow, golden-yellow scales evenly, but sparsely distributed over mesonotum, fewer on humeral angles where they are replaced by similar white scales. Scutellum yellow with few yellow scales and with several long, fine, black hairs evenly distributed. Postnotum black, with silvery pruinosity, devoid of hairs. Pleurae evenly silvery pruinose. Halteres with yellowish-brown stem and yellowish-white knob. Wings, 3.5 mm. long; Sc pilose at least along distal half, often along its entire extent; R<sub>1</sub> pilose only along the distal three-fifths; R<sub>2+3</sub> simple (R<sub>2+4</sub> absent); without hairs along the basal 0.2 mm. beginning where it continues distad from basal section of radius at radio-medial cross-vein; Cu<sub>2</sub> arcuate; discal cell absent.



*Simulium (Dyarella) yepocapense*, n. sp. FIG. 23. Adminicular arm and lateral plate. FIG. 24. Adminiculum of male. FIG. 25. Sidepiece and clasper of male (ventral view), and apex of clasper (dorsal view) showing terminal spine. FIG. 26. Cocoon with enclosed pupa (dorsal view).



Legs: Coxae brownish-black; trochanters yellow with short, black hairs. Leg 1—Length, 2.9 mm.; femur with very small, black band at apex, the remainder yellow. Tibia with base and apex bearing a black band, middle section yellow. Tarsus completely black. Leg 2—Length, 2.7 mm.; femur with same pattern as on leg 1. Tibia with basal two-fifths divided into yellow band, followed by darker band, then by a narrower yellow band; apical three-fifths black. Tarsus with basal two-thirds of basitarsus, and basal one-third of second segment yellow; remainder of these segments, as well as all of the third, fourth, and fifth segments black. Leg 3—Length, 3.2 mm.; femur yellow with black apical band. Some females have only the basal two-fifths yellow, the remainder dark. Tibia with same color pattern as for leg 2. Tarsus with basal three-fifths of basitarsus yellow, apical end black; basal third of second tarsal segment yellow, the rest black. Calcipala and pedisulcus well developed (fig. 20); third, fourth, and fifth tarsal joints black; claw with basal, spear-like projection (fig. 20).

Abdomen: Tergites of first two segments and pleurites of second segment yellowish-brown and covered with silvery-white pruinosity; pleurites of first abdominal segment with extensive posterior fringe of golden-yellow hairs; third, fourth, and fifth segments velvety-black when viewed from above; all segments posterior to these, dark brown and shiny.

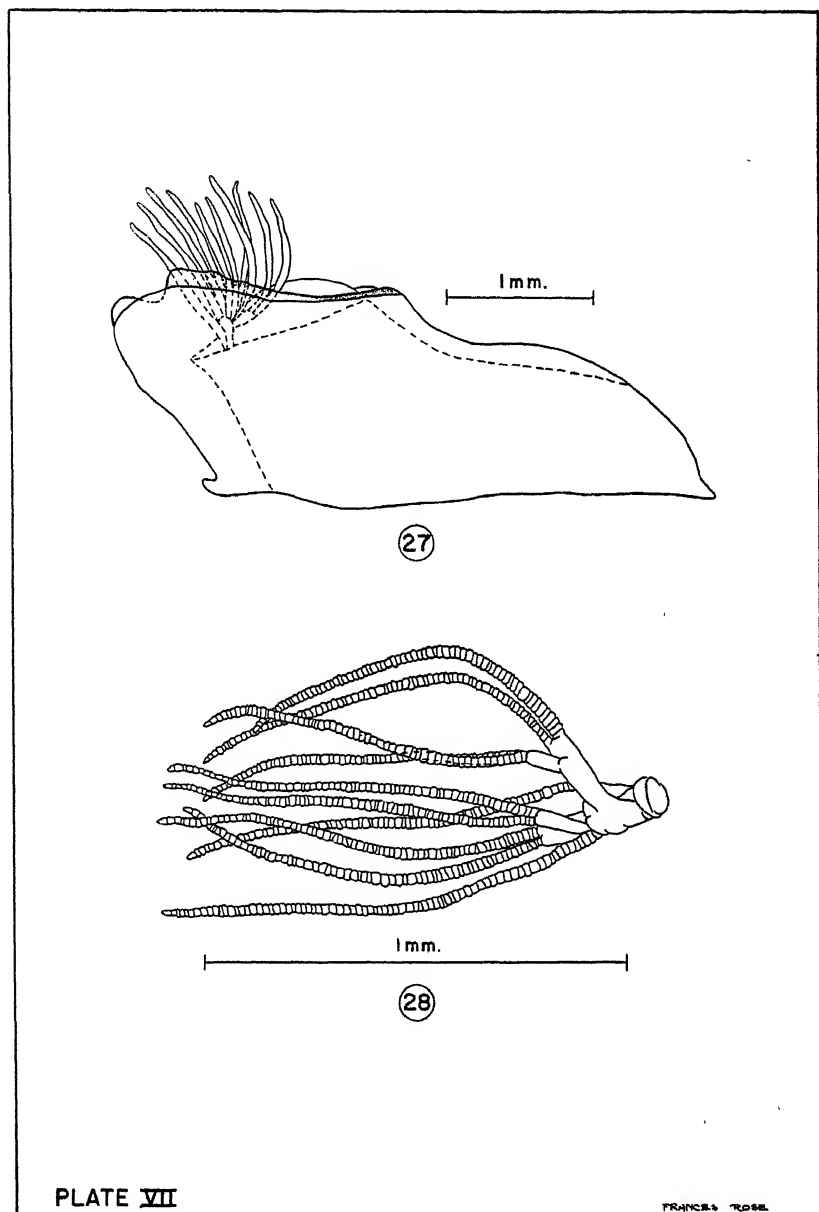
Genitalia: Cercus oval. Anal lobe with dorsal projection; ventral extremity broad. Ovipositor long and lance-like, directed horizontally backward, extending to posterior margin of anal lobe (fig. 21). Genital rod of equal thickness throughout; at point of branching the two arms are connected by a triangular, membranous-like structure; space between the arms quadrangular, almost completely closed in by the interior basal projections of the apical expansions; expansions of each arm triangular, the exterior basal angle approximately  $90^{\circ}$ ; the interior basal angle so acute that it appears more like a tooth-like protuberance; apical angle acute, but not in form of protuberance; hypotenuse of expansion with wave-like margin (fig. 22).

*Male*.—2.8 mm. long. Holoptic. External color patterns almost identical to those of female. Scales on mesonotum longer than on female. Wings, 2.7 mm. long, with same characters as wings of female except that Sc of male is bare along its entire length.

Legs: Leg 1—Length, 2.9 mm.; coxa and trochanter yellow; femur, tibia, and tarsus with same color patterns as on female. Leg 2—Length, 2.3 mm.; coxa black, trochanter dark brown; femur with same pattern as on female; tibia: from base to apex there is a narrow yellow band, followed by a wider dark band, then a very broad yellow band covering about three-fifths of the tibia, and finally, an apical dark band; tarsus with basal two-thirds of basitarsus yellow, the rest of it, as well as the second through fifth segments, black. Leg 3—Length, 2.9 mm.; coxa dark brown, trochanter yellow; femur, tibia, and tarsus with same color patterns as on leg 2.

Abdomen: With same markings as female except for the addition of a lateral, pruinose patch on the pleurites of the sixth segment.

Genitalia: Clasper longer than wide, 2.2 times the length of the sidepiece; without internal processes; apex of clasper roundly blunt,



*Simulium (Dyarella) yepocapense*, n. sp. FIG. 27. Cocoon with enclosed pupa (lateral view). FIG. 28. Pupal filaments of right side (mesial view).

with short, broad spine (fig. 25). Sidepiece wider than long. Main body of adminiculum wider than long, the apex with a depression from which extends a small crown of short spines. Sides of adminiculum appear to be in the form of wing-like expansions which appear delineated from the central body and which reach almost to the base of the basal processes; basal processes short and more heavily sclerotized than the rest of the adminiculum (fig. 24). Adminicular arms with numerous teeth of various sizes, grouped in a wave-like progression, the distal ones long and forming a club-like apex; lateral plate of arm broadly triangular (fig. 23).

*Pupa*.—Cocoon: Greatest length, 4.3 mm.; width at widest point, 1.8 mm. Cocoon slipper-shaped with well-developed collar. Anterior aperture oval with long axis only one-seventh shorter than the length of the dorsum of cocoon when viewed from above (fig. 26). In profile, rim of anterior aperture appears parallel to base of cocoon (fig. 27). Posterior part of rim thickened, gradually becoming thinner as it extends laterally, and forming two delicate extensions anteriorly. Case with fine, parchment-like texture, woven along approximately one-half of its base.

Filaments: The ten filaments comprising the respiratory apparatus of each side are tubular and short (up to 1.0 mm. in length), in most specimens hardly extending beyond the rim of the anterior aperture. They are arranged in two main trunks dorsal and ventral, each of which contains groups of 2-2-1 filaments. All filaments branch at the base or very close to it (fig. 28) and have transverse striations.

The pupal filaments and male genitalia of *yepocapense* most closely resemble those of *S. (D.) hinmani* Vargas (4). However, the two species can be readily distinguished. In the latter species the pupal filaments are proportionately longer and more tapering, and the striations are so pronounced that the filaments appear to be composed of a chain of discs, the centers of which are inflated and approximated. The thoracic region of the pupa is completely covered by short spines and bears up to ten trichomes; both the spines and trichomes are absent in *yepocapense*. The subcosta of wing of female *hinmani* is bare along its entire length while in *yepocapense* the distal half is pilose. The posterior margin of abdominal tergites 3 through 5 of *hinmani* bear a broad, grey-pruinose band while these same areas are distinctly velvety-black in *yepocapense*. The adminiculum of *hinmani* is also less expanded laterally and the clasper is narrower. The cocoon of *yepocapense* is similar to that of *mexicanum* Bellardi but it has the rim around the anterior aperture parallel to the base of the cocoon rather than at an angle to it. The anterior projections of the collar are also much less pronounced in *yepocapense*.

*Ecological Notes*.—This species has been found to date, only on the Pacific slope of the volcanoes Acateango and Fuego. The altitude zone extends from 3,500 to 4,800 feet. In all collections made, the streams seemed to be larger, and faster flowing than the majority of streams in the region. The average width of streams is 14 feet; average depth, 13 inches; average temperature, 19° C.; average pH, 7.2 (almost always in alkaline waters); the speed of streams ranges from 15 to 35 inches per second. The substratum of the streams is composed in all

cases of sand, mixed with small and large stones, and with sparse emergent vegetation. The species has been found throughout the year, almost always on rocks and stones that are exposed to the sun; rarely found on leaves, or in the shade. Other species found associated with it are: *S. mexicanum* Bellardi, *pulverulentum* Knab, *rubicundulum* Knab, *smarti* Vargas, and *callidum* Dyar & Shannon.

*Types*.—*Holotype*, female (Accession Yepo. 570-8); reared from pupa collected in the Río Sacayá, Finca Niágara, San Pedro Yepocapa (Chimaltenango, Guatemala), on October 4, 1948; collectors, Jorge Alemán and Miguel Xinic; mounted on seven slides including genitalia, legs, wings, head, bucco-pharyngeal apparatus, pupal filaments, and pupal skin; the cocoon has been kept in alcohol. *Allotype*, male (Accession Acat. 220-21); reared from pupa collected August 12, 1948, in the Río Kikiyá, Finca El Naranjo, Acatenango, by Enrique Castillo and Inés Padilla; mounted on five slides consisting of genitalia, wings, legs, pupal filaments, and pupal skin; cocoon preserved in alcohol. *Paratypes*, female (Acat. 220-13) from same accession as allotype; mounted on five slides including head, bucco-pharyngeal apparatus, legs, wings, and genitalia in ventral view (also used in description). Female (Acat. 220-17) from same accession, mounted on four slides which include head and bucco-pharyngeal apparatus, legs, wings, and genitalia. Six females and 2 males (Yepo. 998-1, 4, 7, 12, 9, 10, 11, 8) collected from type locality on April 7, 1949, by Julio Girón; all mounted on minuten nadeln. One female (Yepo. 419-8) collected from type locality on August 24, 1948, by Julio Girón. Two males (Yepo. 327-15, 23) collected from Río Cafetal, Finca Morelia, Yepocapa on July 13, 1948, by Francisco Tórtola and Carlos Ochoa. One female (Yepo. 570-9) collected at type locality on October 4, 1948, by Jorge Alemán and Miguel Xinic. All the above adults were reared from pupae, the skins of which have been preserved in alcohol together with the cocoons.

Holotype, allotype, and paratypes Yepo. 998-1 and 998-8 (female and male) to be deposited in the collection of the United States National Museum; all other paratypes to remain in the collection of the author.

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## ERRATA

Vogt, George B. A Biologically Annotated List of the Buprestidae of the Lower Rio Grande Valley, Texas.

Page 194, under *Polycesta velasco* Cast., 5 should read 6.

Page 198, under *Agrilus neoprosopidis* Knull, 27 should read 37.

Townes, Henry K., and Marjorie C. Townes. A Revision of the Genera of the American Species of Tryphonini (Hymenoptera: Ichneumonidae).

Page 334, line 3. For "Nannaimo," read: Nanaimo.

Page 334, line 4. Omit: "in the Santa Cruz Mts."

Page 334, line 5. After "Redwood Corralitos," add: in the Santa Cruz Mts.

Page 334, line 6. For "Taliac," read: Tallac.

Page 335, line 1. For "B. C.," read: Alta.

Page 343, above "*Paratypes*," add: *Type*: ♀, in woods west across road from Ashford railway station, Ashford, Washington, Aug. 19, 1940, H. & M. Townes (Townes).

Page 346, substitute for line 6: *Paratypes*: 5 ♂, ♀, collected with the type, and ♂, Lake George.

Page 352, line 27. For "tergited," read: tergites.

Page 357, third line from bottom. For 1904, read: 1940.

Page 386, line 7. For "Tuolume," read: Tuolumne.

Page 389, second line from bottom. For "Laneil," read: Laniel.

Page 391, eighth line above footnote. For "Fore wing 4.8 mm. long," read: Fore wing about 4.8 mm. long.

Page 395, line 7. For "tegar," read: tegula.

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